Shelby County
2012 West Nile Virus Report

Shelby County Health Department
Epidemiology Section and Vector Control Program
March 2013

Suggested Citation:
Chakraverty, T., Kmet, J., Carlson, T., Sweat. D., Sprenger, D., Curry, J., Zerwekh, T., Morrow, H. S*helby County 2012 West Nile Virus Report.* Memphis, TN: Shelby County Health Department, Epidemiology Section and Vector Control Program. 2013

Table of Contents

Introduction……………………………..…………………………………………………………......1

Clinical Information …………………………………………………………………………......2

Risk Factors and Protective Strategies…...…………………………………………………..3

Human Case Data and Overview of 2012 West Nile Virus Season ……………………....4

Mosquito Surveillance and Control Methods and Background..…………………………...7

Mosquito Surveillance Data……………………………………………………..………....12

Patterns and Conclusion……………………………...……….…………………………...18

References………………………………..………………………………………………....20

Appendix A: Arboviral Diseases, Neuroinvasive and Non-Neuroinvasive Case Definitions

Appendix B: Detailed Mosquito Surveillance Data Tables

List of Detailed Tables and Figures

Tables   Pages No.

Table 1. Human Cases of West Nile Virus and Deaths, Shelby County and State of Tennessee, 2002-2012……………………..........……..………..……......1

Table 2. Human Cases of West Nile Virus by Sex, Age, Race, Month of Onset, and Clinical Status, Shelby County, TN, 2012………………....……………….......4

Table B1. *Culex* Mosquito Density, Positive Pools, and Percent Positive by Week, Shelby County, TN, 2012………….……………………………………………..B1

Table B2. *Culex* Mosquito Density, Positive Pools, and Percent Positive by Week by Zip Code, Shelby County, TN, 2012……………………………………..………B2

Table B3. Mean Number of *Culex* Mosquitoes per Week, Shelby County, TN, 2007-2012……………...…………………..…………………………………...B3

Figures

Figure 1. Zip Codes with Human Cases of West Nile Virus, Shelby County, TN, 2012...5

Figure 2. Mosquito Trapping Locations, Shelby County, TN, 2012……………………….9

Figure 3. 2012 Weekly Ratio of *C. restuans* to *C.pipiens.C.quinquefasciatus*…...........10

Figure 4. *Culex* Species Mosquito Density by Year, Shelby County, TN, 2007-2012…13

Figure 5. *Culex* Species Mosquito Density Comparison, 2012 vs. 6-year mean (2006-2011), Shelby County, TN……………,……………………………..…13

Figure 6. *Culex* Species Mean Mosquito Density by Zip Code, Shelby County, TN, 2012…………………………………………………….………………...14

Figure 7. Total Number of Mosquito Samples Tested and Number of Positive Samples, Shelby County TN, 2006-2012……………………………………………...15

Figure 8. Number of Positive Pools by Week, 2012 vs 5 Year Mean (2007-2011)….16

Figure 9. Total Number of Positive Pools by Zip Code, Shelby County, TN, 2012……16

Figure 10. Number of Zones by Duration of WNV Persistence, 2012 vs. 5 Year Mean (2007-2011), Shelby County, TN…………………………..……………………….17

Figure 11. Maximum Number of Weeks of Persistent Positive Pools by Zip Code, Shelby County, TN, 2012……………………….…………………………………..18

Introduction

West Nile Virus (WNV), a disease that is transmitted to humans by mosquitoes, has caused many epidemics in the United States since it first appeared in 1999.[4] Efforts targeted at WNV prevention and control have been a priority for the Shelby County Health Department since 2002 when the first cases were identified among Shelby County residents. West Nile Virus has the potential to cause severe and even fatal illness. Currently there is no vaccine to prevent WNV and no medical cure; for patients who have severe disease, intensive supportive therapy is the only form of treatment. West Nile Virus was first detected in the bird population of Shelby County, Tennessee late in the season of 2001. The first human case occurred in September 2002, and there have been a total of 138 cases of WNV and 11deaths through 2012. In 2012, there were 15 WNV cases and no fatalities in Shelby County. The majority of human cases of West Nile Virus within the state of Tennessee since 2002 have occurred in Shelby County.

Table 1. Human Cases of West Nile Virus and Deaths, Shelby County and State of Tennessee, 2002-2012

Year	Total Number of cases in Tennessee	Total Number of cases in Shelby County	Shelby County Fatalities
2002	56	40	7
2003	26	10	0
2004	14	12	0
2005	18	13	0
2006	22	14	0
2007	11	5	0
2008	19	10	1
2009	9	5	1
2010	4	2	0
2011	18	12	2
2012	33	15	0
TOTAL	**230**	**138**	**11**

Case counts include both confirmed and probable cases as determined by the case definitions established by the Centers for Disease Control and Protection[8]

Clinical Information

West Nile Fever

The majority of people who are infected by a mosquito with West Nile Virus are asymptomatic. Those who do become symptomatic primarily show benign symptoms that are collectively referred to as West Nile Fever. This consists of fever, headache, and fatigue that may sometimes be accompanied by a skin rash, swollen lymph glands, and eye pain. The incubation period, which is the time period from being infected to developing symptoms, is thought to range from 2 to 14 days. For those who are immunocompromised, this time interval may be longer.[2]

Severe Neuroinvasive West Nile Virus Disease

When the central nervous system (CNS) is affected, this is referred to as neuroinvasive WNV. Clinical symptoms may range from febrile headache to aseptic meningitis and encephalitis. West Nile meningitis is characterized by the classical symptoms of meningitis (fever, headache and stiff neck) with possible lapses or loss of consciousness. West Nile poliomyelitis, a flaccid paralysis syndrome, is characterized by the acute onset of asymmetric limb weakness or paralysis. This disease has a clinical presentation that is similar to polio. The most severe form of neuroinvasive West Nile viral disease is West Nile encephalitis, and involves severe symptoms like lethargy, confusion, and alteration of consciousness in addition to fever and headache.[2]

Clinical Suspicion and Laboratory diagnosis

WNV infection can be suspected in a person based on clinical symptoms and patient history. [2,8] Laboratory testing is required for a confirmed diagnosis (See Appendix B for more information on diagnosis) . Detailed travel history, date of onset of symptoms, vaccination, and knowledge of similar mosquito and tick-borne diseases need to be considered for people over the age of 50 who present with unexplained neuroinvasive symptoms like encephalitis or meningitis. [8] This is particularly true for Shelby County residents where year-round transmission is a possibility. Since no particular treatment for West Nile Virus is available, intensive supportive therapy is the only option to treat people who become severely ill.[3]

Risk Factors and Protective Strategies

The overall risk of contracting West Nile Virus is dependent on multiple factors. The majority of cases for both Shelby County and the rest of the country have occurred between the months of July and September. Though widely distributed throughout the country, the highest incidence rates are in the western and southern states.[1] Individuals who spend a lot of time outdoors, either occupationally or recreationally, have a greater chance of being bitten by an infected mosquito and contracting the disease.[1] The disease is also more severe in the population greater than age 50 and those who are immunocompromised[1]. There is no person-to-person transmission of West Nile Virus; one develops the infection only after being bitten by an infected mosquito.[1]

Strategies that the public are encouraged to follow during West Nile Virus season include the following[1,11,12].

- Wear DEET-containing mosquito repellants or a repellant containing an EPA-registered active ingredient according to label directions. Shelby County residents are strongly encouraged to refrain from sitting outdoors at night; however, use repellents when outdoors, especially at night, regardless of perceived mosquito activity.
- Eliminate standing water where mosquitoes can lay eggs such as rain gutters. Check properties for objects - including old tires, flower pots and drip plates, tin cans, buckets, and children's toys - that collect rainwater and either drain or dispose of the water.
- Install or repair windows and door screens
- Empty, clean and refill birdbaths and small wading pools weekly
- Empty and refill pets' water bowls every few days
- Repair failed septic systems and leaky outside faucets
- Secure swimming pool covers tightly and store canoes, wheel barrows, and boats upside down.
- Stock ornamental lawn ponds with fish (Gambusia) that eat mosquito larvae (Gambusia fish are available FREE from the Vector Control Program. 190 Shelby County citizens took advantage of this in 2012.)

Human Case Data and Overview of 2012 West Nile Virus Season

The 2012 season had a similar level of activity for West Nile Virus in Shelby County compared to the previous season. For the entire season, there were a total of 15 cases (See Table 2) that were determined by the most recent standard criteria[8] set forth by the Centers for Disease Control and Prevention (CDC) (See Appendix A for CDC criteria). Of these 15 cases, eight were confirmed and seven were probable. None of the 2012 human cases were fatal. In 2011, there were 12 total human cases with 2 fatalities.

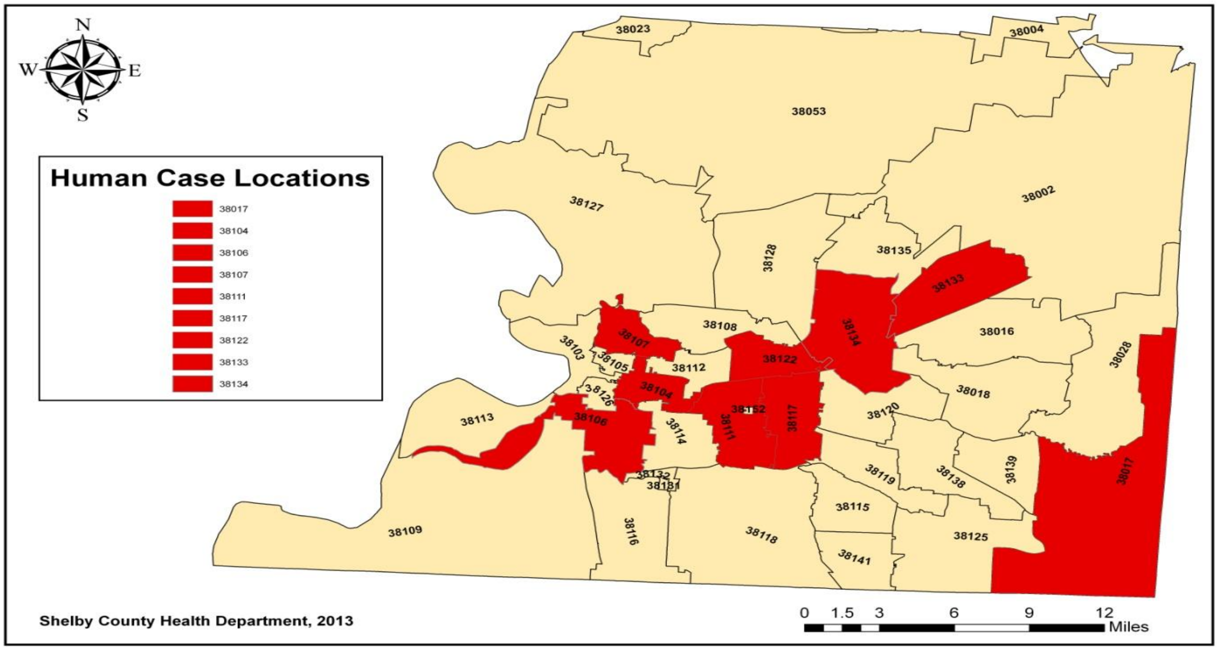
Figure 1 shows the zip code locations where human cases of West Nile Virus resided in Shelby County during the 2012 season. It is important to note that the location of residence may not be the same as the location where a case was bit by an infected mosquito.

Table 2. Human Cases of West Nile Virus by Sex, Age, Race, Month of Onset, and Clinical Status, Shelby County, TN, 2012

Profile of Human WNV Cases, 2012	
	Number of Cases*
Total Number of Cases	15
Sex	
Male	9
Female	6
Age	
Less than age 50	6
Greater than age 50	9
Race	
Black	6
White/Hispanic	9
Month of Onset	
August	6
September	6
October	2
December	1
Clinical Status	
Neuroinvasive	7
Non-neuroinvasive	8

*Case counts include both confirmed and probable cases as determined the case definitions established by the Centers for Disease Control and Protection[8]

Figure 1: Zip Codes with Human Cases of West Nile Virus, Shelby County, TN, 2012



For the 2012 season, there was a severe epidemic of West Nile Virus throughout the entire United States. In total, there were 5,388 cases in the entire nation for 2012, with a near equal distribution between Neuroinvasive and Nonneuroinvasive cases. Of the Neuroinvasive cases, 243 were fatal. This was the largest total number of cases since 2003, and is in contrast to the 712 total nationwide cases and 43 fatalities for the 2011 season. Approximately one-third of the human cases were from the state of Texas. Other states with many human cases include California, Louisiana, Illinois, Mississippi, South Dakota, Michigan, Oklahoma, Nebraska, Colorado, Arizona, Ohio, and New York[13].

The state of Tennessee had a total of 32 total cases with one fatality in 2012, an increase from the 18 cases with two fatalities the previous year. As in previous years, Shelby County had most of these cases (15) in Tennessee for 2012, a slight increase from the 12 cases there were documented in 2011.The majority of the cases (10) had a date of onset during the month of August. There were 2 cases with a date of onset in July, and one each in September and October. The last case in Shelby County had a date of onset in mid-December, which was unexpected since there has never been a human case in Shelby County that presented so late in the year. None of the cases from 2012 were fatal, in contrast to 2 of the 12 cases from 2011 that were fatal. Nine of the cases were male and six were female. The cases ranged in age from the mid-20s to over 70 years of age, with the majority of the cases occurring in adults between 50-59 years old. Seven of the cases were Neuroinvasive and eight were Non-Neuroinvasive. Though there was a small increase in the number of countywide cases, Shelby County was very fortunate this season in comparison with other areas of the country that were severely affected. Much of this may be attributed to the vigilant efforts of the Vector Control Program with targeted spraying(larviciding and adulticiding), as well as overall efforts to inform and educate the public on appropriate prevention measures.

There are many important factors to consider as to why the 2012 season was one of the worst West Nile Virus epidemics in the country. Probably the most important factors are related to weather and climate. *Culex* mosquitoes, the major vector of West Nile virus, thrive in hot, damp conditions. The higher temperatures that were present nationwide during the summer of 2012 and fluctuations between rainfall and drought were ideal conditions for mosquitoes to breed and multiply. In general, areas with many human cases have been linked closely to above average summer temperatures. Unseasonably warm weather may also enable West Nile Virus to spread more easily. Warm weather speeds up both the life cycle of the mosquito and the multiplication of West Nile Virus. This essentially allows infected mosquitoes to reach a biting age quicker. Significant increases in West Nile cases have also been associated with one or more days of heavy rain within a week of the case increase and continuing for the next two weeks. Another important climate factor to consider is the mild winter and early spring season that was present in 2012. This extended the time period that mosquitoes posed a definite threat. Mosquitoes are able to quickly repopulate themselves and are stimulated to bite during humid conditions. At the same time, drought-like conditions drive birds into more densely populated areas in search of water with mosquitoes behind them. When birds and mosquitoes spend more time together during drought conditions, younger birds may become more easily infected with the virus and spread it to mosquitoes, which then spread it to humans leading to higher rates of West Nile Virus transmission. Finally, an additional contributing factor to the severe cycle of West Nile Virus nationwide could be an overall decline in the diversity of bird populations. Some prior studies have found a ‘dilution effect’ or inverse correlation between bird diversity and West Nile incidence. In other words, the more species of birds there are in an area, the lower the rate of West Nile Virus[14].

In 2012 Texas had the largest proportion of cases nationwide (primarily in the greater Dallas area), and Texas also experienced the most severe drought conditions in 2012. During a drought, there is a greater chance of more polluted water. As water evaporates in periods of extreme heat, the pollutants will still remain. In urban areas, like Dallas, there may have been many polluted ponds and urban streams that provided the ideal conditions for *Culex* mosquitos to thrive and multiply. Furthermore, underground sewers, catch basins and abandoned houses with swimming pools or birdbaths also may contain stagnant water that provides the nutrient conditions for mosquitoes to flourish[15].

Mosquito Surveillance and Control Methods and Background

The transmission cycle of West Nile Virus involves birds as the reservoir for the virus and mosquitoes as vectors that transmit the disease. The principal vectors responsible for transmitting WNV in Shelby County are adult female mosquitoes of the *Culex* species that primarily rest during the day and bite humans and animals throughout the night. *Culex* mosquitoes tend to breed in stagnant water sources that range from artificial containers to large bodies of permanent water. These mosquitoes thrive in water that contains organic material which is common in urban areas with inadequate drainage and sanitation.[5]

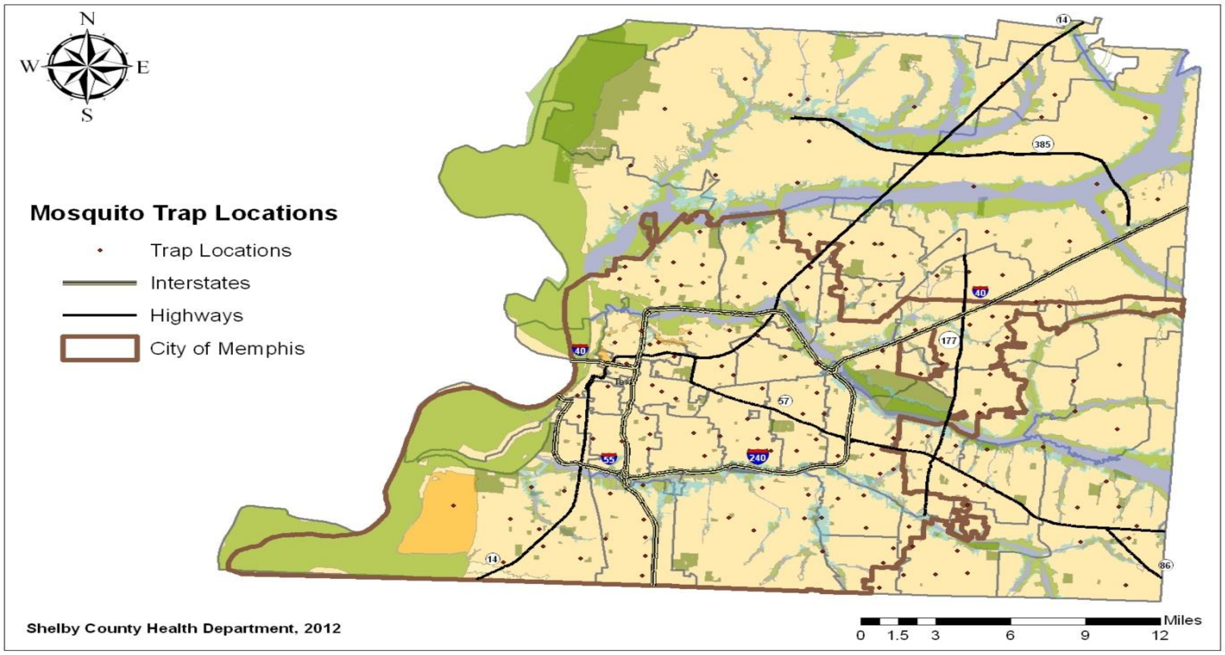
Detection and control of WNV in mosquito populations are the primary tools that help health officials prevent human and domestic animal infections. Viral activity is currently monitored primarily through mosquito and human surveillance to pinpoint specific areas of high risk within Shelby County. The Health Department uses an integrated mosquito management program, which includes several components: (1) surveillance (monitoring levels of mosquito activity and where virus transmission is occurring), (2) source reduction of mosquito breeding sites, (3) use of chemical and biological methods to control mosquito larvae (larviciding), (4) use of chemical methods to control adult mosquitoes (adulticiding), and (4) community outreach and public education. Larvicides are products used to kill immature mosquitoes. If applied directly to water sources that hold mosquito eggs or larvae, the number of new mosquitoes can be limited. Adulticides are products used to kill adult mosquitoes. The ultimate goal of adulticiding is to reduce the number of mosquitoes that can bite people and possibly transmit WNV. Source reduction is the alteration or elimination of stagnant water sources that foster mosquito larval habitat breeding. It is the most cost-effective method that can include individual activities (proper tire disposal, cleaning bird baths, swimming pools and rain gutters) or water management projects by environmental agencies [3].

The Vector Control Program catalogs the locations of water producing mosquito larvae throughout Shelby County. Currently, there are approximately 3,000 sites. Larval sites are inspected from mid-March through the end of October, and information on the number and type of larvae is collected. The sites are classified as producing vector mosquitoes (mosquitoes that can transmit the virus) or nuisance mosquitoes. Vector sites may contain nuisance mosquitoes, but sites designated as nuisance sites do not contain vector mosquitoes. In 2012, there were approximately 1288 nuisance sites and 3089 vector sites. The county is divided into 15 areas and a larviciding crew is assigned to each area. Depending on the time of year and surveillance information, crews are assigned to either a 'nuisance site itinerary' (inspecting all sites identified as producing nuisance mosquitoes) or a 'vector site itinerary' (inspecting all sites identified as producing vector mosquitoes). The nuisance site itinerary will include vector sites that also produce nuisance mosquitoes. All sites on the assigned itinerary are inspected by a larviciding crew every two weeks and treated based on criteria called action thresholds (described later).

Adult vector mosquitoes are trapped from late-April to late-October and information is collected on type, number, and the presence of WNV-positive mosquitoes. WNV mosquito testing runs from May 1st to the end of October. The county is divided into 163 zones, sized based on the area an adulticide truck can treat in three hours. A gravid trap is placed in a centralized location in each zone. These traps are designed to collect adult female *Culex* mosquitoes preparing to lay their eggs. Each trap runs for 12 hrs overnight, typically once a week. Samples are sent to the State of Tennessee to be tested for West Nile Virus. The decision to adulticide a location is dependent on adulitciding action thresholds. Zones that do not meet the action threshold requirements will not be adulticided.

Action thresholds are established by Shelby County Health Department Division of Vector Control and then approved by Tennessee Department of Environment of Conservation under the authority of the United States Environmental Protection Agency. The action threshold for larval mosquitoes is based on the presence or absence of larval mosquitoes in a water sample taken using a standard 12 oz dipper. The action threshold for mosquito larvae and pupae is an average of one mosquito per dip per site.[12] The action threshold for adult vector mosquitoes is based on whether or not the vector mosquitoes have tested positively for a disease pathogen that can be a threat to human health. This includes West Nile Virus and a similar virus that causes St. Louis Encephalitis. When disease pathogens are detected the action threshold will be one mosquito per trap per night and when disease pathogens are not detected then the action threshold will be not lower than 50 mosquitoes per trap per night. When an action threshold is met or exceeded, adulticiding may be initiated. Zones are prioritized for adulticiding based on mosquito surveillance findings. Recent human case locations are also taken into account when prioritizing adulticiding schedules. Figure 2 shows the current mosquito trapping locations in Shelby County.

Figure 2. Mosquito Trapping Locations, Shelby County, TN, 2012



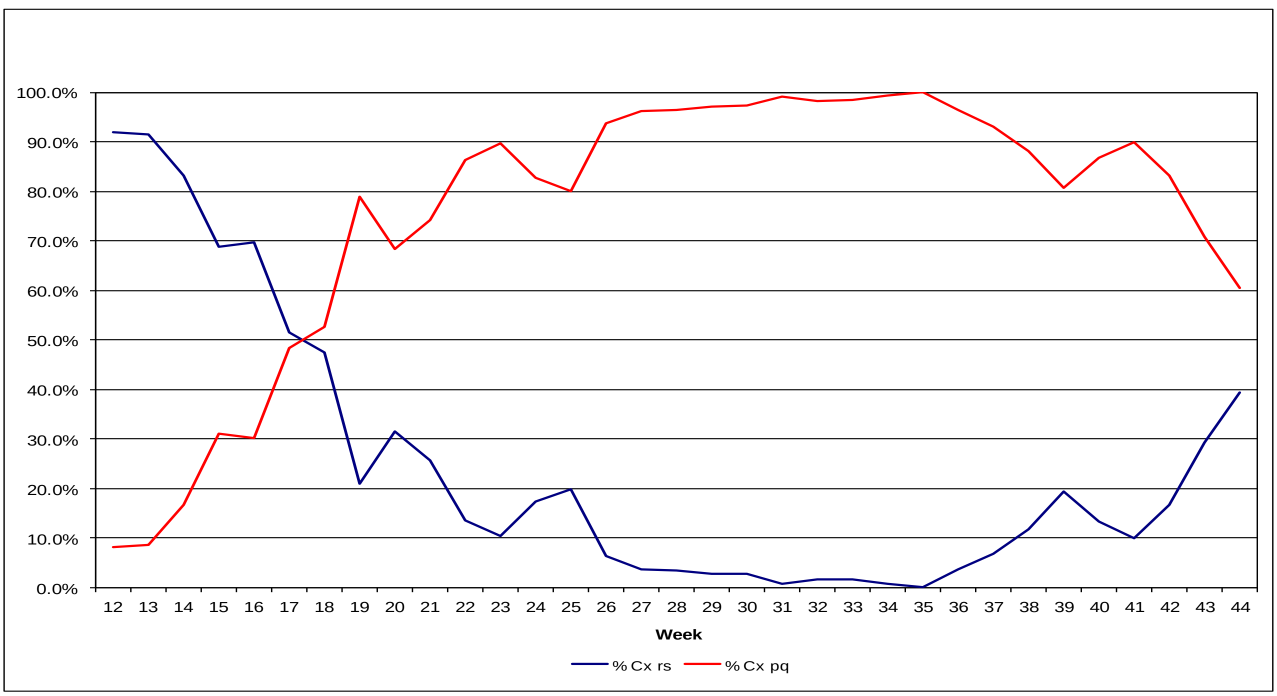
Abatement of West Nile Virus (WNV) relies in part upon the timing and targeting of control efforts to the particular phases and events of the outbreak as they occur. This requires mapping and calculating a number of statistics that depict the dynamics of an outbreak. The initial phase of a WNV outbreak involves the circulation of the virus in birds and mosquitoes.   Infected blood-feeding mosquitoes pass the virus to birds, which in turn, develop sufficient levels of virus in their blood to lead to the infection of more blood-feeding mosquitoes. More and more birds and mosquitoes become involved in the cycle and the size of the area in which this is occurring gradually increases.

The general dynamics of each WNV outbreak are similar to one another; however, the exact location and the time that the virus will first occur and subsequently appear differs from year to year. As a precaution, Vector Control conducts larval inspection and treatment activities throughout the county before WNV activity begins. Larvae can develop from eggs deposited daily upon the water's surface. Vector Control larvicides the County on a schedule of once every two weeks. The larvicide's killing capability diminishes greatly after two weeks.

Larviciding is conducted from mid-March, when the first mosquitoes (*Aedes, Ochlerotatus* and *Psorophora* species) hatch from their winter eggs, until the end of October. The beginning of the season is devoted to larviciding nuisance sites containing *Aedes, Ochlerotatus,* and *Psorophora* species. This is the time of year when these species are most numerous.

Also prevalent in early spring is the *Culex restuans* species (white-spotted mosquito). This particular *Culex* species appears to be a poor vector of WNV because even when infected mosquitoes are identified, amplification or geographical expansion of the virus is not seen. White-spotted mosquitoes will naturally disappear; therefore, Shelby County does not engage in WNV vector control until house mosquitoes, *Culex quinquefasciatus* (northern house mosquito) and *Culex pipiens* (southern house mosquito), become plentiful. White-spotted mosquitoes are prevalent in the early spring, when house mosquitoes are absent. Gradually, as Memorial Day approaches, the number of white-spotted mosquitoes diminishes as they enter a state of dormancy during the summer. At the same time, house mosquitoes leave winter hibernation and begin to appear. Geographical expansion only occurs as the ratio of the house mosquito larvae (*Culex pipiens and Culex quinquefasciatus)* to white-spotted mosquito larvae (*Culex restuans*) increases. Vector Control tracks the ratio of white-spotted mosquito larvae to house mosquito larvae as a type of threshold to trigger larviciding vector mosquito sites.

Figure 3. 2012 Weekly Ratio of *C. restuans* to *C.pipiens.C.quinquefasciatus*



May is the earliest month when mosquitoes can be sent for WNV testing. This schedule is set by the State of Tennessee. The first positive samples are usually detected at the same time that the transition of the *Culex* species occurs, typically around Memorial Day. Historically, the first positive locations have been in Memphis, Bartlett or Germantown. The virus is typically found much later in Collierville, Millington, Lakeland, Arlington and unincorporated Shelby County. Crews have begun to larvicide vector sites by the middle of May, at first detection of the virus, or when there has been an overwhelming prevalence of house mosquitoes.

Events surrounding an outbreak do not change the larviciding program. Weather however does have an influence. As sites dry in the summer, inspections become less necessary. The decision to cease inspection comes from the historical records of each site.

Adulticiding on the other hand is "shaped" by the dynamics of the outbreak. Disease foci are centers of amplification and are targeted for control in order to slow the expansion of the virus. Vector Control is required to extend this service to all localities in the county given that the service is paid for by all citizens through the Vector Control fee. The maximum number of zones that Vector Control can adulticide in one week is 40 zones, due to a limited amount of trucks and equipment. At times, the number of WNV positive zones will exceed 40 zones per week and adulticiding then is done on a rotational basis, which means each zone is adulticided about once a month. The entire county is sprayed at least two to four times per year at the rate of once per month.

While areas that have been identified as WNV disease foci are targeted for adulticiding, Vector Control does not specifically target areas for adulticiding based on vector mosquito densities. Densities often fluctuate week to week even without the effect of control. However, mosquito density can be an important factor in identifying areas that have had septic contamination. Sites are tracked by density groupings, e.g. 50-100, 100-500, over 500. Large numbers of house mosquitoes may be produced (e.g. 4,000-8,000 per trap night) if there is septic contamination of a creek or sewage outcropping. These areas will be larvicided and adulticided when necessary. The policy of the Health Department calls for public notification before spraying. These notifications are made through the media in the form of press releases and are posted on the Shelby County Website. Press releases are prepared weekly; therefore, spraying for high numbers may only be performed after a week of detection at the earliest.

Source reduction has been recently incorporated into larviciding operations for greater efficiency. Larviciding crews are charged with improving drainage as they conduct their inspections by removing trash and objects, such as used tires, that could generate mosquitoes. This work has only been performed during the winter months in past years. The crews have also been charged with making referrals to Health Department inspectors to have properties cleaned up if the accumulations of trash are greater than what they can remove in one or two trips. During the winter months, Health Department inspectors continue to actively locate tire piles for removal.

Mosquito Surveillance Data

Mosquito Density

Mosquito density, the mean number of mosquitoes per trap, is an important surveillance measure. Specifically, mosquito density helps Vector Control to focus their control efforts with respect to larviciding. It helps to identify sources or problem areas within the county where there are unusually high numbers of mosquitoes. As previously described, each week a gravid trap is placed in each of 163 zones for a 12-hour period; therefore, the mosquito density for each week reflects the mean number of mosquitoes collected per zone in a one night, 12-hr trap catch.

Figure 4 shows the mean number of *Culex* mosquitoes collected per trapping event for each of the past 6 years. Overall, 2012 demonstrated a significant increase in number of mosquitoes compared to the previous two seasons. Figure 5 shows a weekly comparison of mosquito density between the 2012 season and the average of the six previous seasons (2006-2011). Mosquito density was larger in 2012 during the first week of testing (week 19) than in the average of the previous six years. For the most part, mosquito density in 2012 was comparable to the average of the six previous years with the exception of a very large peak during week 23 of the 2012 season when an exceptionally large number of *Culex* mosquitoes were collected. Figure 6 shows the geographic distribution of the mean mosquito density by zip code. Zip codes where human cases were located are outlined in blue. Most of the areas with the highest mosquito densities are within the city of Memphis.

Figure 4. *Culex* Species Mosquito Density by Year, Shelby County, TN, 2007-2012

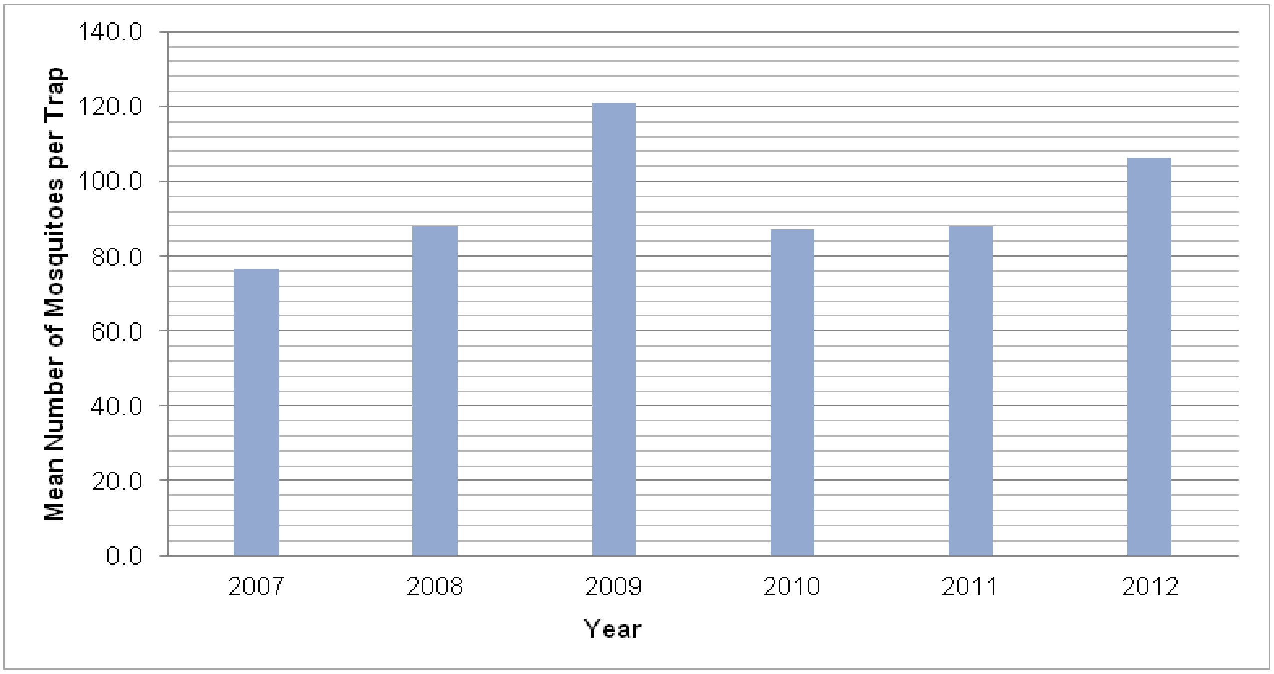


Figure 5. *Culex* Species Mosquito Density Comparison, 2012 vs. 6 Year Mean (2006-2011), Shelby County, TN.

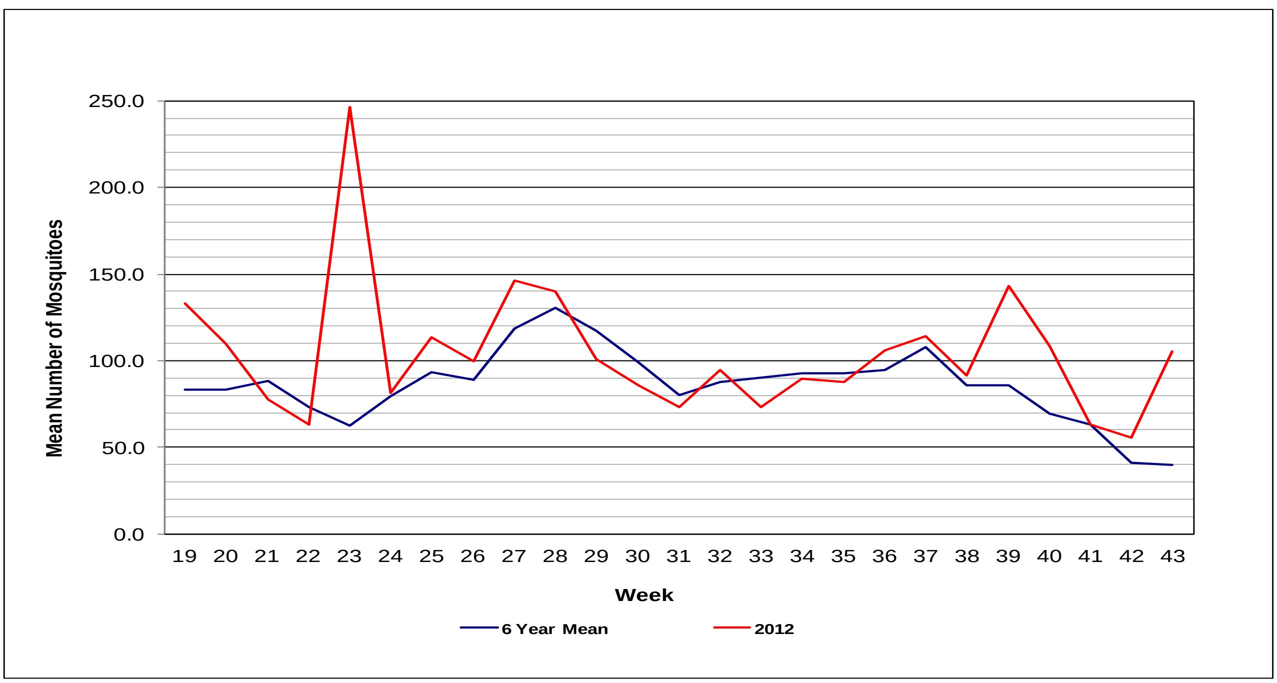
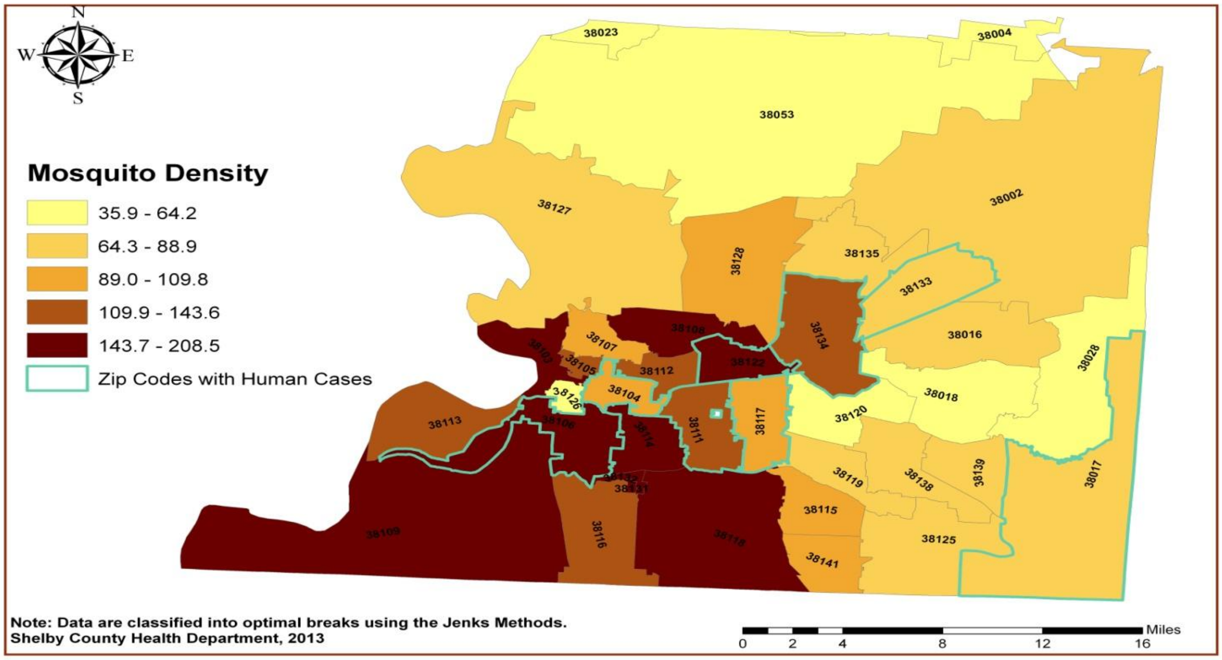


Figure 6. *Culex* Species Mean Mosquito Density by Zip Code, Shelby County, TN, 2012



WNV-Positive Mosquitoes and Persistent Positive Zones

When mosquitoes are sent to be tested for WNV, they are sent in groups that are collectively referred to as a mosquito 'pool'. In general, a mosquito pool can consist of up to 50 mosquitoes depending on how many mosquitoes are collected in the trap. For a mosquito pool to test positive, there only needs to be one WNV-positive mosquito in the pool. Thus, when a mosquito pool tests positive, it is not known how many of the mosquitoes in that pool are positive. For a trapping zone to be considered 'positive' for a specific week there must be at least one WNV-positive pool from that zone. Figure 7 shows the total number of mosquitoes tested and the total number of samples positive from 2007 to 2012. In 2012, there were 830 positive samples out of a total of 3583 samples tested (23%). This is a slight decrease from the 2011 season where there were 974 positive samples out of a total of 3623 samples tested (27%).

Figure 7. Total Number of Mosquito Samples Tested and Number of Positive Samples, Shelby County TN, 2006-2012

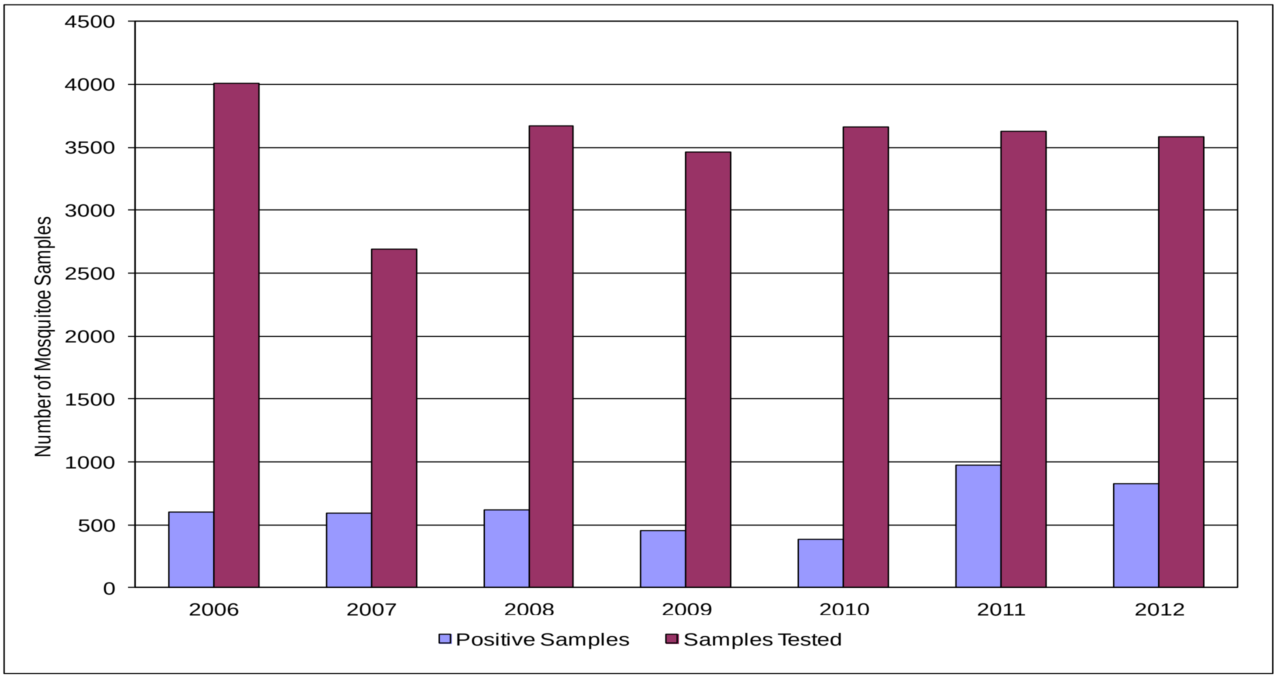


Figure 8 shows the total number of positive pools by week comparing the 2012 season to the mean for the previous five years. It can be seen that the overall weekly number of positive pools for the 2012 season was higher than the previous five-year mean (2007-2011) for most of the season except for the last six weeks and also peaked mid-season from weeks 26 to 33. Figure 9 shows the total number of positive pools by zip code. Particularly high numbers of positive pools can be seen in pockets throughout the central (Bartlett), southern (Memphis) and eastern (Collierville) areas of Shelby County.

Figure 8. Number of Positive Pools by Week, 2012 vs 5 Year Mean (2007-2011)

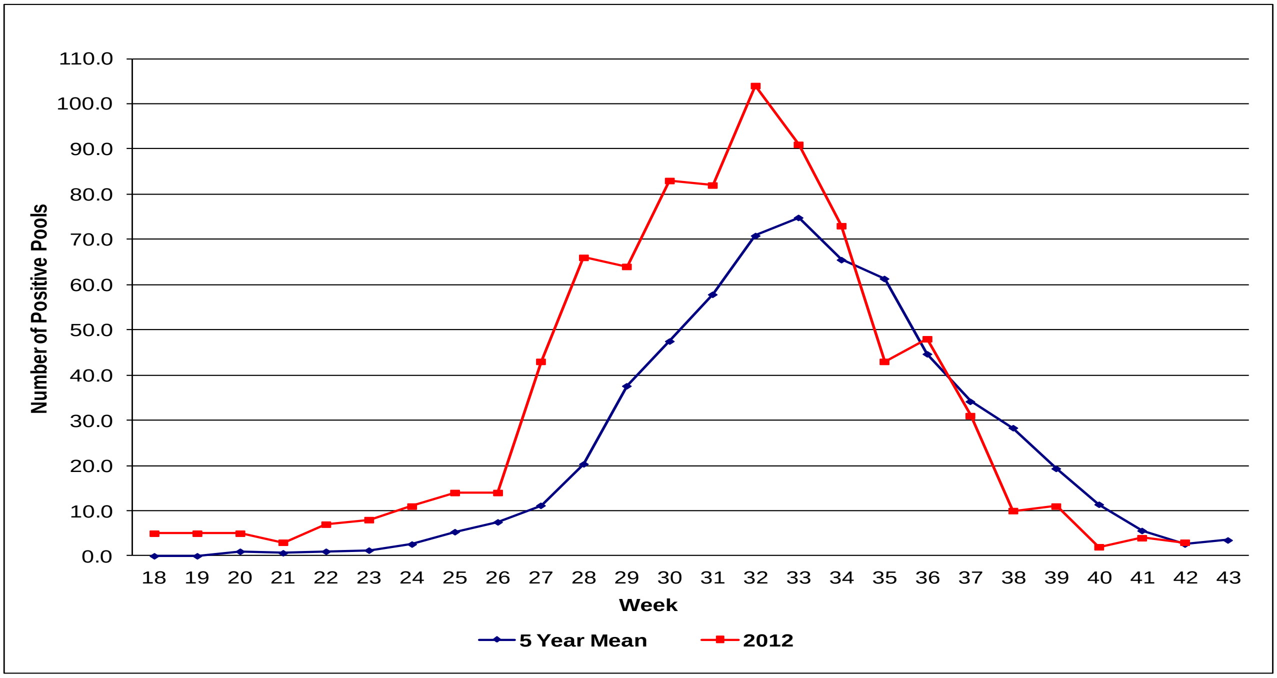
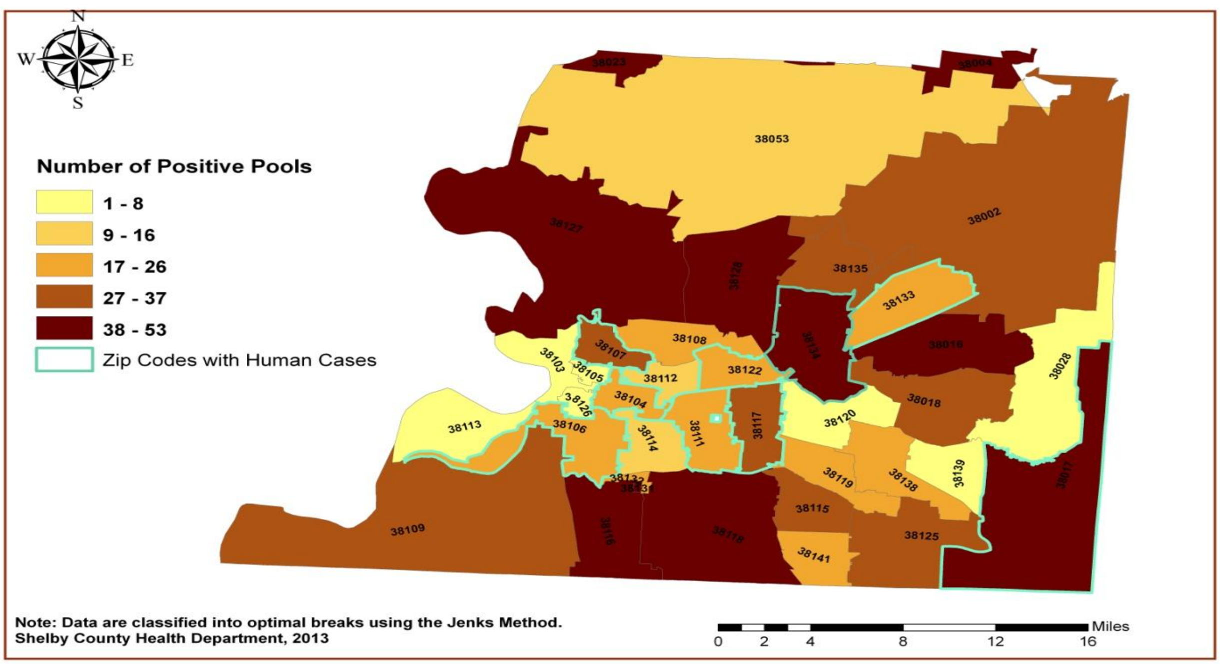


Figure 9. Total Number of Positive Pools by Zip Code, Shelby County, TN, 2012



West Nile Virus persistence is another measure utilized by the Vector Control section to target control measures. Persistence is measured as the number of weeks between when a zone first tests positive to the last week it tests positive.

Figure 10 shows the number of zones by their duration of viral persistence for the 2012 season compared to the mean for the previous five years (2006-2011). For example, in the 2012 season there were only five zones that never tested positive for WNV (0 weeks of persistence) compared to a mean of about 20 zones in the previous five seasons, and in 2012 there were 13 zones that tested positive for 11 weeks compared to a mean of approximately eight zones with this duration of persistence in the previous five seasons. In general, there were many more zones that had long durations of viral persistence in 2012 than there were in the previous five seasons.

Figure 11 depicts persistence by zip code, or the maximum number of consecutive weeks that any zone within a particular zip code has tested positive. Persistent positive areas can be detected diffusely throughout the county, though more concentrated in the central, southeastern and eastern areas.

Figure 10. Number of Zones by Duration of WNV Persistence, 2012 vs. 5 Year Mean (2007-2011), Shelby County, TN

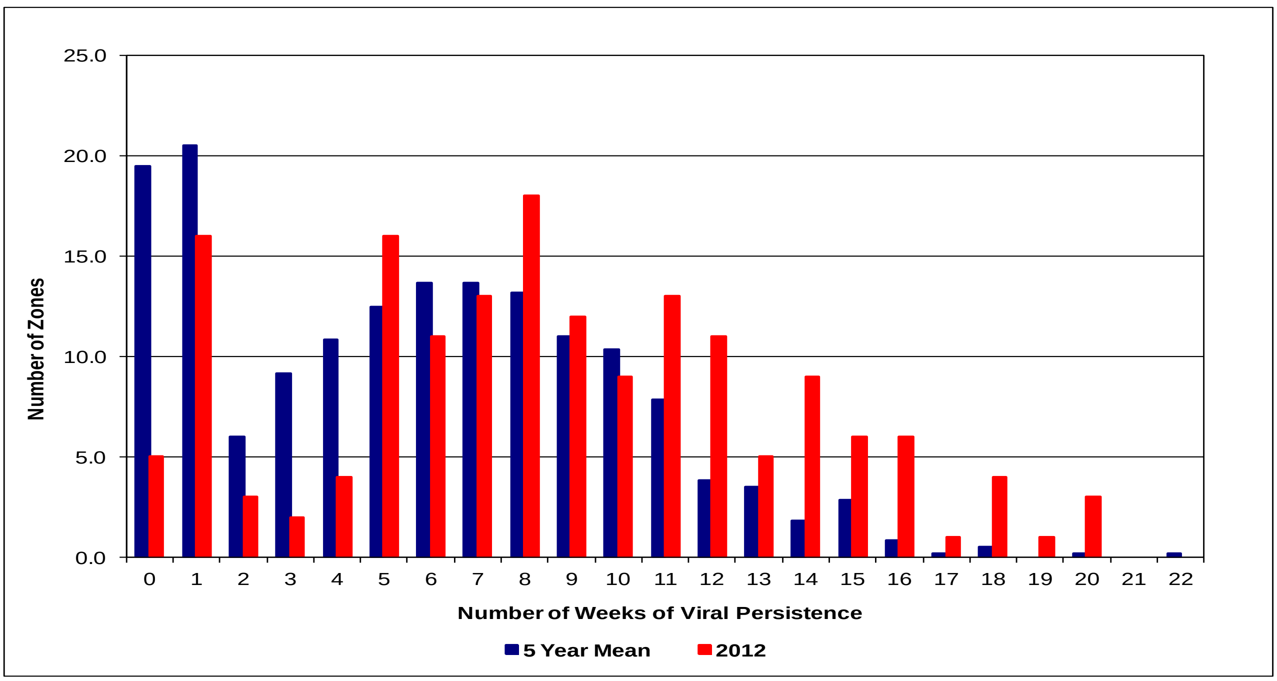
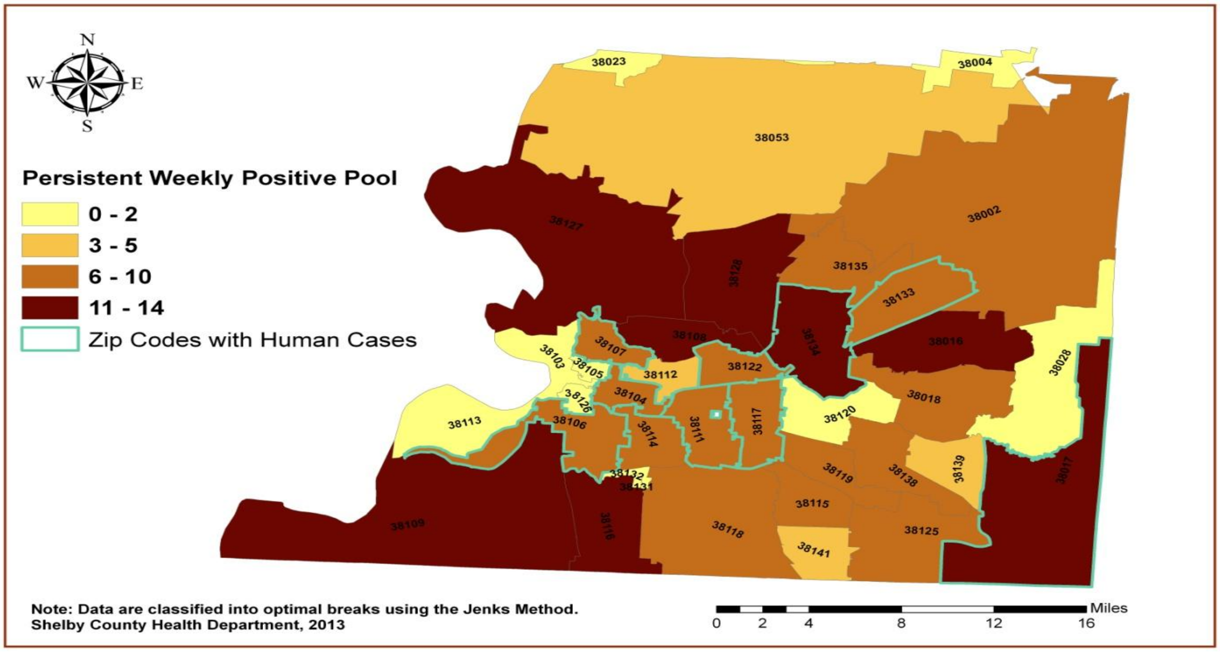


Figure 11. Maximum Number of Weeks of Persistent Positive Pools by Zip Code, Shelby County, TN, 2012



Patterns and Conclusion

For the 2012 season, there were 15 total cases with no fatalities, compared with only 12 cases and two fatalities in 2011 and 2 cases and no fatalities in 2010. Overall, the increase in the number of human cases in 2012 coincides with higher numbers of positive pools earlier in the season and more zones with long durations of viral persistence compared to the previous five-year mean. In 2012, there was a sharp increase in overall mosquito density. However, it is difficult to identify a clear pattern between the location of the human cases and mosquito surveillance data, particularly with regard to mosquito density and positive pools. Case locations appear to coincide to some extent with areas having persistent positive activity. The low virulence of West Nile Virus may contribute to a lack of detectable pattern. It is estimated that approximately 80% of individuals infected with WNV have no detectible symptoms or only mild symptoms that can be mistaken as a cold or the flu.[2] As a result, only the more severe cases are identified and reported. With a sample size of only about 20% of cases identified, a clear pattern may not be readily detectable.

Furthermore, there are numerous factors in addition to the presence of WNV-infected mosquitoes which can contribute to how each case became infected, including but not limited to: travel both within and outside the county, outdoor activity, use of insect repellants, screens on windows, other housing factors, population density, age, etc. Many of these factors likely vary with the economic status of communities. Human behaviors impact the rate at which people become infected. For example, there may be a high level of 'risky behavior' (i.e. being outdoors at dusk without using repellent) among people living in areas with low levels of West Nile Viral activity and relatively low levels of risky behavior in areas with high levels of West Nile Viral activity, or vice versa.

Although there was a slight increase in the number of human cases, Shelby County was very fortunate to not have any fatalities or be affected by the severe nationwide epidemic of West Nile Virus in 2012. To ensure that future human cases of West Nile Virus are minimized, there are many factors that are used to target prevention and control measures given limited resources. Areas of the county where mosquitoes tend to breed are a definite focus of early mosquito control efforts. Vector Control larvicides throughout the county in anticipation of the virus appearing anywhere within the county. Secondly, mosquito surveillance is conducted to both identify where viral activity is occurring and to adulticide the zones in which it is occurring, as well as the adjacent zones in an attempt to slow expansion and amplification. Zones with positive persistent mosquito pools collected for more than one week are monitored very closely. The locations of human cases are also considered. It is crucial to implement not only mosquito abatement efforts but public education measures as well. Citizens are encouraged to be vigilant as it relates to controlling mosquito populations around their homes and businesses, as well as to use personal protective measures to reduce their likelihood of becoming infected. The Shelby County Health Department will continue to take action during the West Nile Virus season to protect and inform our citizens.

References

1. Mayo Clinic Staff. Mayo Clinic. West Nile Virus. Scottsdale, Arizona. 2004. Available from: http://www.mayoclinic.com/health/west-nile-virus/DS00438

2. Centers for Disease Control and Prevention. West Nile Virus: Clinical Description. 2008. Available from: http://www.cdc.gov/ncidod/dvbid/westnile/clinicians/clindesc.htm

3. Centers for Disease Control and Prevention. Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control. 2003. Available from: http://www.cdc.gov/ncidod/dvbid/westnile/resources/wnv-guidelines-aug-2003.pdf

4. Kilpatrick A.M., Kramer L.D., Jones M.J., Marra P.P., Daszak P. West Nile Virus Epidemics in North America Are Driven by Shifts in Mosquito Feeding Behavior. PLoS Biol, 4(4). 2006.

5. Petersen L.R., Hayes E.B., Westward H.O.? The Spread of West Nile Virus. N Engl J, Med 351: 2257–2259. 2004.

6. Brault A.C., Langevin S.A., Bowen R.A., Panella N.A., Biggerstaff B.J., et al. Differential virulence of West Nile strains for American crows. Emerg Infect Dis,10: 2161–2168. 2004.

7. Spielman A., Andreadis T.G., Apperson C.S., Cornel A.J., Day J.F., et al. Outbreak of West Nile virus in North America. Science, 306: 1473–1473. 2004.

8. Centers for Disease Control and Prevention. Arboviral Diseases, Neuroinvasive and Non-Neuroinvasive. 2011. Available from: http://www.cdc.gov/osels/ph_surveillance/nndss/casedef/arboviral_current.htm

9. Shelby County Government. Shelby County Health Department, Department of Vector Control :West Nile. Shelby County, TN. 2011.

10. Centers for Disease Control and Prevention. West Nile Virus: Updated Information regarding Insect Repellents. Available from: http://www.cdc.gov/ncidod/dvbid/westnile/RepellentUpdates.htm.

11. State of Tennessee. NPDES Permit: General NPDES Permit for Discharges from the Application of Pesticides. Available from: http://www.tn.gov/environment/wpc/forms/cn0759_tnp100000.pdf.

12. Centers for Disease Control and Prevention. West Nile Virus: What You Need to Know. 2012. Available from: http://www.cdc.gov/ncidod/dvbid/westnile/wnv_factsheet.htm.

13. Centers for Disease Control and Prevention. West Nile Virus: Fight the Bite. 2012. Available from http://www.cdc.gov/ncidod/dvbid/westnile/index.htm.

14. Butler, Kiera. “What's Causing the West Nile Virus Outbreak?” Mother Jones. 15 October 2012. 10 January 2013. Available from http://www.motherjones.com/environment/2012/10/west-nile-virus-maps.

15. Jaslow, Ryan. “What's making the 2012 West Nile virus outbreak the worst ever?” CBS News. 25 August 2012. 10 January 2013. Available from http://www.cbsnews.com/8301-504763_162-57500089-10391704/whats-making-the-2012-west-nile-virus-outbreak-the-worst-ever.

Appendix A

Arboviral Diseases, Neuroinvasive and Non-Neuroinvasive Case Definitions[8]

2011 Case Definition

(Replicated from http://www.cdc.gov/osels/ph_surveillance/nndss/casedef/arboviral_current.htm)

CSTE Position Statement Numbers: 10-ID-18, 10-ID-20, 10-ID-21, 10-ID-22, 10-ID-23, 10-ID-24

California Serogroup Viruses, (i.e., California encephalitis, Jamestown Canyon, Keystone, La Crosse, Snowshoe hare, and Trivittatus viruses)
Eastern Equine Encephalitis Virus
Powassan Virus
St. Louis Encephalitis Virus
West Nile Virus
Western Equine Encephalitis Virus

Background

Arthropod-borne viruses (arboviruses) are transmitted to humans primarily through the bites of infected mosquitoes, ticks, sand flies, or midges. Other modes of transmission for some arboviruses include blood transfusion, organ transplantation, perinatal transmission, consumption of unpasteurized dairy products, breast feeding, and laboratory exposures.

More than 130 arboviruses are known to cause human disease. Most arboviruses of public health importance belong to one of three virus genera: *Flavivirus*, *Alphavirus*, and *Bunyavirus*.

Clinical description

Most arboviral infections are asymptomatic. Clinical disease ranges from mild febrile illness to severe encephalitis. For the purposes of surveillance and reporting, based on their clinical presentation, arboviral disease cases are often categorized into two primary groups: neuroinvasive disease and non-neuroinvasive disease.

<u>Neuroinvasive disease</u>
Many arboviruses cause neuroinvasive disease such as aseptic meningitis, encephalitis, or acute flaccid paralysis (AFP). These illnesses are usually characterized by the acute onset of fever with stiff neck, altered mental status, seizures, limb weakness, cerebrospinal fluid (CSF) pleocytosis, or abnormal neuroimaging. AFP may result from anterior ("polio") myelitis, peripheral neuritis, or post-infectious peripheral demyelinating neuropathy (i.e., Guillain-Barré syndrome). Less common neurological manifestations, such as cranial nerve palsies, also occur.

Non-neuroinvasive disease

Most arboviruses are capable of causing an acute systemic febrile illness (e.g., West Nile fever) that may include headache, myalgias, arthralgias, rash, or gastrointestinal symptoms. Rarely, myocarditis, pancreatitis, hepatitis, or ocular manifestations such as chorioretinitis and iridocyclitis can occur.

Clinical criteria for diagnosis

A clinically compatible case of arboviral disease is defined as follows:

Neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, AND
- Meningitis, encephalitis, acute flaccid paralysis, or other acute signs of central or peripheral neurologic dysfunction, as documented by a physician, AND
- Absence of a more likely clinical explanation.
-

Non-neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, AND
- Absence of neuroinvasive disease, AND
- Absence of a more likely clinical explanation.

Laboratory criteria for diagnosis

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, OR
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, OR
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, OR
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred, OR
- Virus-specific IgM antibodies in CSF or serum.

Case classification

Confirmed:
Neuroinvasive disease
A case that meets the above clinical criteria for neuroinvasive disease and one or more the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, OR
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, OR
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, OR
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

Non-neuroinvasive disease
A case that meets the above clinical criteria for non-neuroinvasive disease and one or more of the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, OR
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, OR
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, OR
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

Probable:
Neuroinvasive disease
A case that meets the above clinical criteria for neuroinvasive disease and the following laboratory criteria:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.

Non-neuroinvasive disease
A case that meets the above clinical criteria for non-neuroinvasive disease and the laboratory criteria for a probable case:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.

Comment

Interpreting arboviral laboratory results

- **Serologic cross-reactivity.** In some instances, arboviruses from the same genus produce cross-reactive antibodies. In geographic areas where two or more closely-related arboviruses occur, serologic testing for more than one virus may be needed and results compared to determine the specific causative virus. For example, such testing might be needed to distinguish antibodies resulting from infections within genera, e.g., flaviviruses such as West Nile, St. Louis encephalitis, Powassan, Dengue, or Japanese encephalitis viruses.
- **Rise and fall of IgM antibodies.** For most arboviral infections, IgM antibodies are generally first detectable at 3 to 8 days after onset of illness and persist for 30 to 90 days, but longer persistence has been documented (e.g, up to 500 days for West Nile virus). Serum collected within 8 days of illness onset may not have detectable IgM and testing should be repeated on a convalescent-phase sample to rule out arboviral infection in those with a compatible clinical syndrome.
- **Persistence of IgM antibodies.** Arboviral IgM antibodies may be detected in some patients months or years after their acute infection. Therefore, the presence of these virus-specific IgM antibodies may signify a past infection and be unrelated to the current acute illness. Finding virus-specific IgM antibodies in CSF or a fourfold or greater change in virus-specific antibody titers between acute- and convalescent-phase serum specimens provides additional laboratory evidence that the arbovirus was the likely cause of the patient's recent illness. Clinical and epidemiologic history also should be carefully considered.
- **Persistence of IgG and neutralizing antibodies.** Arboviral IgG and neutralizing antibodies can persist for many years following a symptomatic or asymptomatic infection. Therefore, the presence of these antibodies alone is only evidence of previous infection and clinically compatible cases with the presence of IgG, but not IgM, should be evaluated for other etiologic agents.
- **Arboviral serologic assays**. Assays for the detection of IgM and IgG antibodies commonly include enzyme-linked immunosorbent assay (ELISA), microsphere immunoassay (MIA), or immunofluorescence assay (IFA). These assays provide a presumptive diagnosis and should have confirmatory testing performed. Confirmatory testing involves the detection of arboviral-specific neutralizing antibodies utilizing assays such as plaque reduction neutralization test (PRNT).
- **Other information to consider.** Vaccination history, detailed travel history, date of onset of symptoms, and knowledge of potentially cross-reactive arboviruses known to circulate in the geographic area should be considered when interpreting results.

Imported arboviral diseases

Human disease cases due to Dengue or Yellow fever viruses are nationally notifiable to CDC using specific case definitions. However, many other exotic arboviruses (e.g., Chikungunya, Japanese encephalitis, Tick-borne encephalitis, Venezuelan equine encephalitis, and Rift Valley fever viruses) are important public health risks for the United States as competent vectors exist that could allow for sustained transmission upon establishment of imported arboviral pathogens. Health-care providers and public health officials should maintain a high index of clinical suspicion for cases of potentially exotic or unusual arboviral etiology, particularly in international travelers. If a suspected case occurs, it should be reported to the appropriate local/state health agencies and CDC .

Appendix B

Detailed Mosquito Surveillance Data Tables

Table B1. *Culex* Mosquito Density, Positive Pools, and Percent Positive by Week, Shelby County, TN, 2012

Week	Number of Mosquitoes Collected	Mean Number of *Culex* Mosquitoes per Trap	Number of Pools Tested	Number of Positive Pools	Percentage of Positive Pools
18	9510	79.9	127	5	3.9
19	20717	132.8	145	5	3.4
20	17756	109.6	145	5	3.4
21	12418	77.6	145	3	2.1
22	9858	62.8	145	7	4.8
23	37407	246.1	145	8	5.5
24	12409	81.6	145	11	7.6
25	17809	113.4	145	14	9.7
26	15632	99.6	145	14	9.7
27	17693	146.2	145	43	29.7
28	22080	139.7	145	66	45.5
29	15533	100.9	145	64	44.1
30	13214	85.8	145	83	57.2
31	11109	73.1	145	82	56.6
32	15043	94.6	145	104	71.7
33	11548	73.1	145	91	62.8
34	13970	89.6	145	73	50.3
35	9965	87.4	145	43	29.7
36	15790	106.0	145	48	33.1
37	16455	114.3	145	31	21.4
38	14579	91.7	145	10	6.9
39	22792	143.3	145	11	7.6
40	17358	108.5	145	2	1.3
41	9791	63.2	145	4	2.8
42	8937	55.5	145	3	2.1
43	16260	105.6	57	0	0

Table B2. *Culex* Mosquito Density, Positive Pools, and Percent Positive by Week by Zip Code, Shelby County, TN, 2012

Zip Code	Total Number of Mosquitoes Collected	Mosquito Density	Number of Positive Pools
38002	14,999	77.0	28
38016	17,724	88.9	46
38017	13,141	80.4	40
38018	9,191	62.3	37
38028	2,439	35.9	2
38053	15,775	62.6	16
38103	5,000	208.3	1
38104	8,772	92.5	19
38105	2,914	116.6	4
38106	22,477	173.0	26
38107	13,452	109.8	30
38108	11,797	168.7	24
38109	35,544	173.8	30
38111	13,540	118.1	21
38112	5,570	118.2	11
38114	7,199	160.9	12
38115	9,668	99.6	30
38116	22,661	130.5	45
38117	13,193	109.5	28
38118	26,249	153.5	43
38119	8,427	83.3	20
38120	1,603	61.7	6
38122	10,843	208.5	19
38125	11,759	70.1	36
38126	1,164	52.9	3
38127	17,450	75.0	41
38128	21,303	104.3	47
38133	6,794	69.3	23
38134	22,165	143.6	52
38135	11,014	76.0	37
38138	10,613	82.2	23
38139	3,888	77.5	8
38141	7,305	99.5	18

Table B3. Mean Number of *Culex* Mosquitoes per Week, Shelby County, TN, 2007-2012

Week	2007	2008	2009	2010	2011	2012
19	64.9	124.0	123.7	44.7	83.7	132.8
20	39.6	86.8	73.7	112.5	76.3	109.6
21	76.8	93.8	97.3	85.9	90.5	77.6
22	54.0	105.8	85.1	39.1	66.6	62.8
23	54.2	43.7	73.5	55.0	47.4	246.1
24	139.1	46.5	72.2	74.5	65.9	81.6
25	138.1	63.9	113.6	92.8	72.7	113.4
26	92.6	67.0	87.0	134.5	100.4	99.6
27	77.4	158.6	164.5	149.4	112.1	146.2
28	73.8	93.5	210.6	237.7	138.4	139.7
29	82.9	129.8	236.7	62.6	139.4	100.9
30	60.0	103.1	106.8	97.2	138.0	85.8
31	53.4	81.1	127.9	73.3	92.0	73.1
32	81.7	73.6	152.9	71.1	89.4	94.6
33	45.3	73.7	137.2	68.2	141.6	73.1
34	53.3	89.5	191.5	62.5	94.0	89.6
35	66.3	101.6	147.4	66.1	99.7	87.4
36	80.6	87.3	151.2	106.6	85.2	106.0
37	73.6	152.3	171.2	118.1	88.9	114.3
38	94.1	66.4	92.0	126.1	113.4	91.7
39	100.1	98.6	74.9	95.2	101.8	143.3
40	66.4	81.5	121.7	51.5	62.5	108.5
41	88.6	51.9	43.1	65.3	53.9	63.2
42	--	86.8	--	46.1	17.7	55.5
43	--	38.8	50	42.1	45.7	105.6