Shelby County
2015 West Nile Virus Report

Shelby County Health Department
Epidemiology Section and Vector Control Program
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Table of Contents

Introduction……..…….....1

Clinical Information …….....2

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

Human Case Data and Overview of 2015 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, 2002-2015…….....……..……..…….....1

Table 2. Human Cases of West Nile Virus by Sex, Age, Race, Month of Onset, and Clinical Status, Shelby County, TN, 2015……....…….....4

Table B1. *Culex* Mosquito Density, Positive Pools, and Percent Positive by Week, Shelby County, TN, 2015…….……..B1

Table B2. Mean Number of *Culex* Mosquitoes per Week, Shelby County, TN, 2007-2015……...……..……...B3

Figures

Figure 1. Zip Codes with Human Cases of West Nile Virus, Shelby County, TN, 2015...5

Figure 2a. Shelby County Vector Control Operational Zones of Mosquito Abatement…8

Figure 2b. Mosquito Trapping Locations, Shelby County, TN, 2015……..9

Figure 3. 2015 Weekly Ratio of *C. restuans* to *C.pipiens.C.quinquefasciatus*….....11

Figure 4. *Culex* Species Mosquito Density by Year, Shelby County, TN, 2007-2015…13

Figure 5. *Culex* Species Mosquito Density Comparison, 2015 vs. 9-year mean (2006-2014), Shelby County, TN……,……..…14

Figure 6. *Culex* Species Mean Mosquito Density by Operational Zone, Shelby County, TN, 2015…….……...14

Figure 7. Total Number of Mosquito Samples Tested and Number of Positive Samples, Shelby County TN, 2006-2015……...15

Figure 8. Number of Positive Pools by Week, 2015 vs 9 Year Mean (2006-2014)….16

Figure 9. Total Number of Positive Pools by Zip Code, Shelby County, TN, 2015……17

Figure 10. Number of Zones by Duration of WNV Persistence, 2015 vs. 9 Year Mean (2006-2014), Shelby County, TN……..……18

Figure 11. Maximum Number of Weeks of Persistent Positive Pools by Zip Code, Shelby County, TN, 2015…….……..19

Introduction

West Nile Virus (WNV), a disease transmitted to humans by mosquitoes by an arthropod-borne virus (arbovirus), 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 158 cases of WNV and 12 fatalities through 2015. In 2015, there was only one nonfatal West Nile Virus case. 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, 2002-2014

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
2013	24	9	1
2014	16	10	1
2015	8	1	0
TOTAL	**270**	**157**	**13**

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, 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.)

Human Case Data and Overview of 2015 West Nile Virus Season

The 2015 season had a very mild level of activity for West Nile Virus in Shelby County compared to the previous season. For the entire season, there was only one case (See Table 2) that was 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). This one case was confirmed by the CDC standards and was not fatal. In 2014, there were 10 total human cases with one fatality.

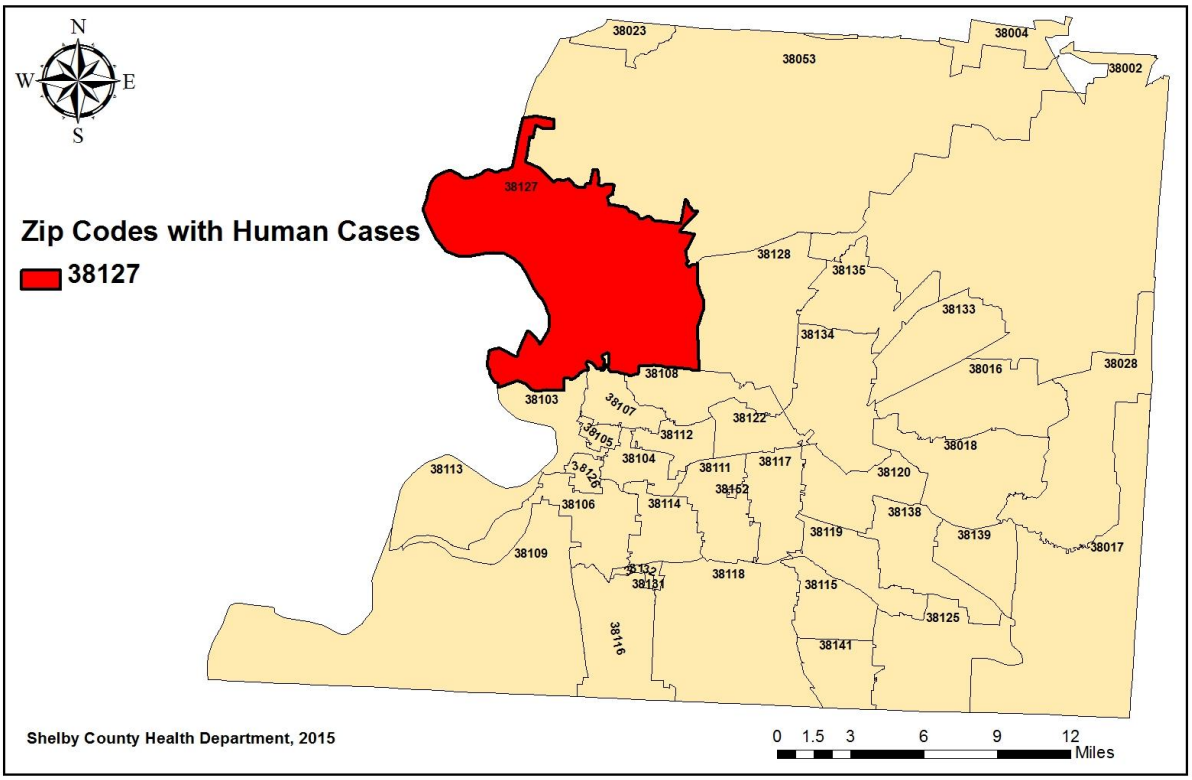
Figure 1 shows the zip code locations where human cases of West Nile Virus resided in Shelby County during the 2015 season. It is important to note that the location of residence may not be the same as the location where a case was bitten by an infected mosquito.

Table 2. Human Cases of West Nile Virus by Sex, Age, Race, Month of Onset, and Clinical Status, Shelby County, TN, 2015

Profile of Human WNV Cases, 2015	
	Number of Cases*
Total Number of Cases	1
Sex	
Male	1
Female	0
Age	
Less than age 50	0
Greater than age 50	1
Race	
Black	1
White	0
Month of Onset	
July	1
Clinical Status	
Neuroinvasive	1
Non-neuroinvasive	0

*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, 2015



Nationwide, the 2015 season was less severe than the 2013 season in terms of overall human West Nile Virus cases[13]. There were 1,370 cases nationwide in 2015 as compared to 2,122 cases in 2014. States with more than 100 human cases of West Nile Virus in 2015 include California with 544 and Texas with 181.

The state of Tennessee had a total of 8 cases with no fatalities in 2015, as compared to 16 cases with one fatality the previous year. Unlike most previous years, Shelby County did not have the most cases in the state for 2015. Davidson County had 2 cases, while Shelby, Rutherford, Crockett, Blount, Sumner and Loudon each had one case. The only case in Shelby County had an onset of illness in July. This was a confirmed, neuroinvasive case in an African-American male over the age of 50 who fully recovered. The drastic decrease in the number of human cases countywide from the previous year in 2014(10to 1) can be attributed tp the vigilant efforts of the Vector Control Program with targeted spraying (larviciding and adulticiding), as well as the overall efforts to inform and educate the public on appropriate prevention measures.

There are many important factors to consider with regards to variation in the number of human cases. 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. Higher temperatures 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 mild winters and early spring seasons, which extends the time period that mosquitoes can pose 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].

Furthermore, during a drought, there is a greater chance of more polluted water in urban settings. As water evaporates in periods of extreme heat, the pollutants will still remain. Polluted ponds and urban streams provide the ideal conditions for *Culex* mosquitos to thrive and multiply. 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

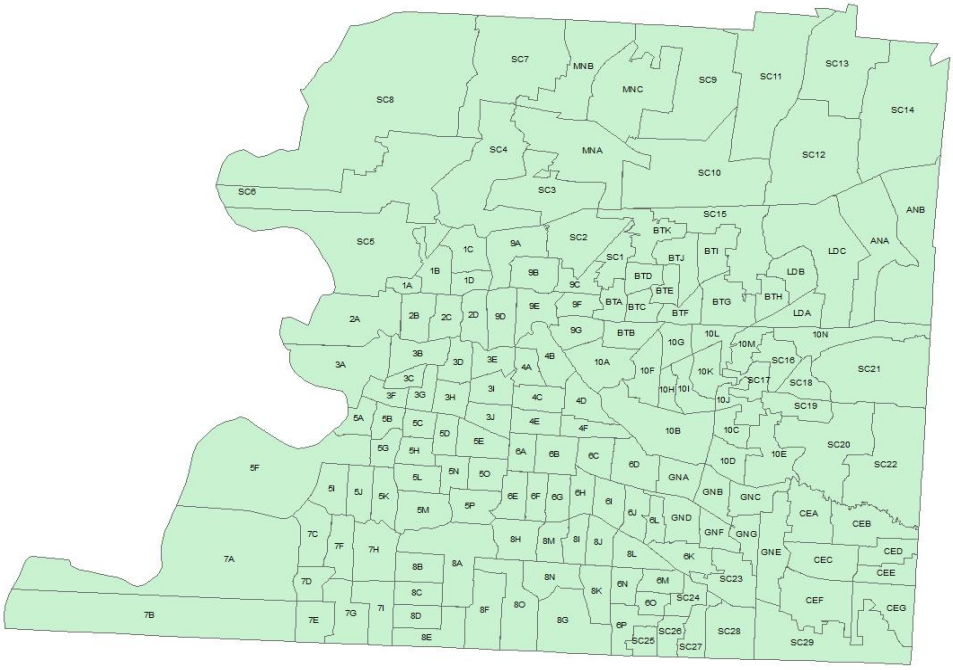
monitored primarily through mosquito and human surveillance to pinpoint specific areas of high risk within Shelby County. The Health Department uses an integrated mosquito management program, which includes several components: (1) surveillance (monitoring levels of mosquito activity and where virus transmission 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 2015, there were approximately 1515 nuisance sites and 1702 vector sites. The county is divided into 17 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

adulticiding action thresholds. Zones that do not meet the action threshold requirements will not be adulticided.

Figure 2a. Shelby County Vector Control Operational Zones of Mosquito Abatement

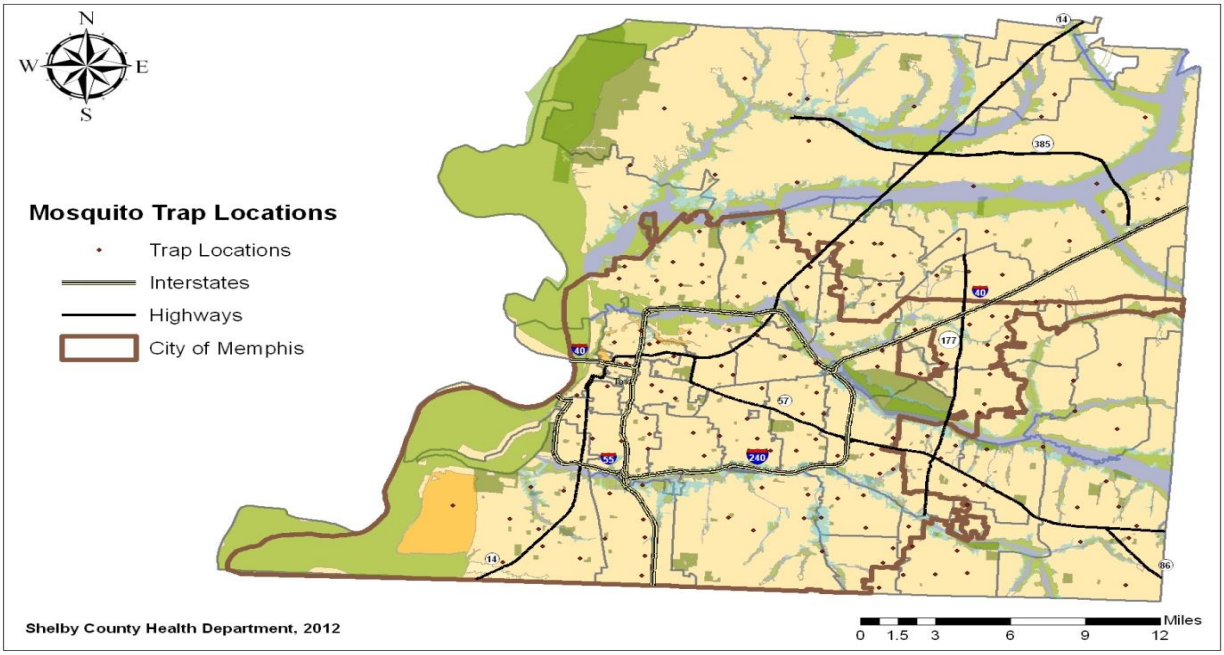


Action thresholds are established by Shelby County Health Department Division of Vector Control and then approved by Tennessee Department of Environment of Conservation under the authority of the United States Environmental Protection Agency. The action threshold for larval mosquitoes is based on the 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 (http://www.cdc.gov/sle/). St. Louis Encephalitis is an Arboviral disease in the same family as West Nile Virus. In 2015, there were 11positive mosquito pools for St. Louis Encephalitis, compared to 24 pools last year. The last recorded human case of St. Louis Encephalitis in Shelby County was in 2005.

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 action thresholds, mosquito species/density, particular disease (West Nile Virus, SLE) and overall human health risk. Recent human case locations are also taken into account when prioritizing adulticiding schedules.

Figure 2b. Mosquito Trapping Locations, Shelby County, TN, 2015



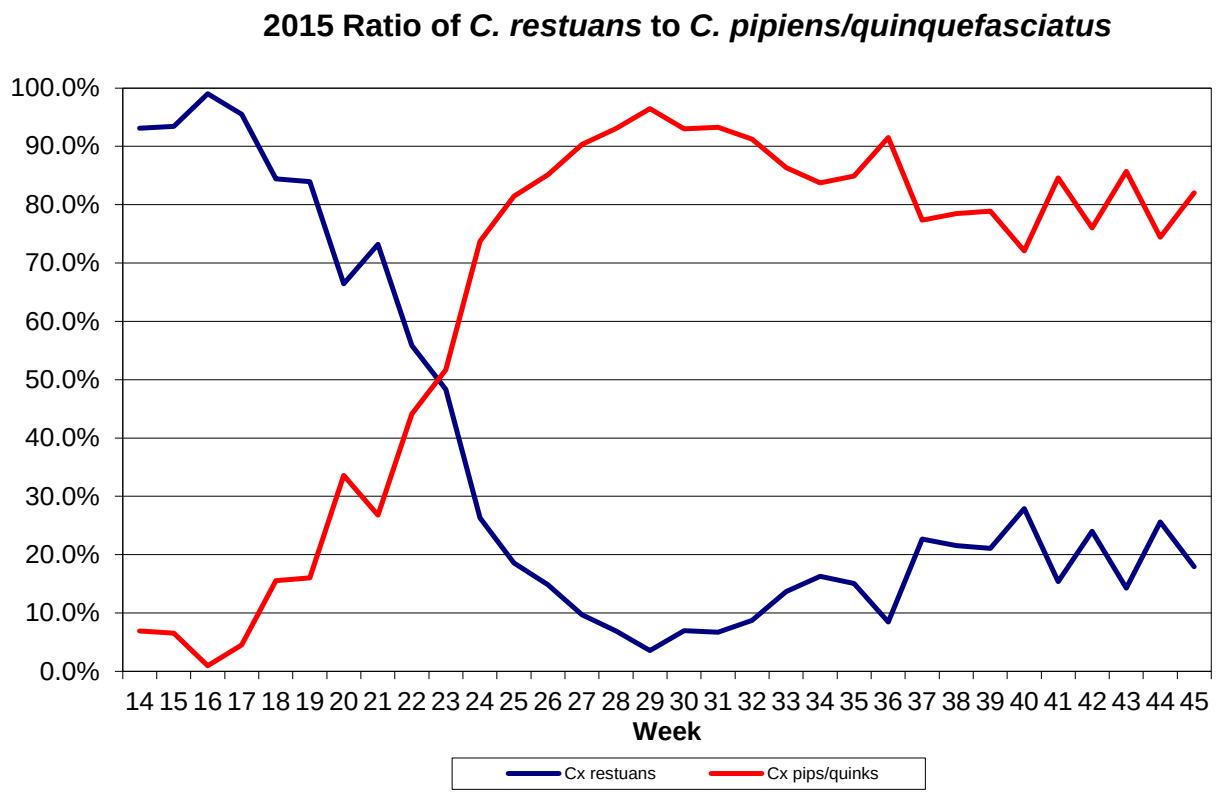
Abatement of West Nile Virus (WNV) relies in part upon the timing and targeting of control efforts to the particular phases and events of the outbreak as they occur. This requires mapping and calculating a number of statistics that depict the dynamics of an outbreak. The initial phase of a WNV outbreak 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 differ 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 approximately 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. 2015 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 per trap night. 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 (http://www.shelbycountytn.gov/CivicAlerts.aspx) and are posted on the Shelby County website (http://www.schdresponse.com). 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, 2015 demonstrated a moderate decrease in the number of mosquitoes compared to the previous season. Figure 5 shows a weekly comparison of mosquito density between the 2015 season and the average of the eight previous seasons (2006-2014). Mosquito density was roughly comparable to the average of the previous seasons with the exception at the end where there were was a noticeable spike Figure 6 shows the geographic distribution of the mean mosquito density by vector operational zone. Most of the areas with the highest mosquito densities are within the city of Memphis and the Bartlett area, which is similar to the density distribution of the previous year.

Figure 4. *Culex* Species Mosquito Density by Year, Shelby County, TN, 2007-2015

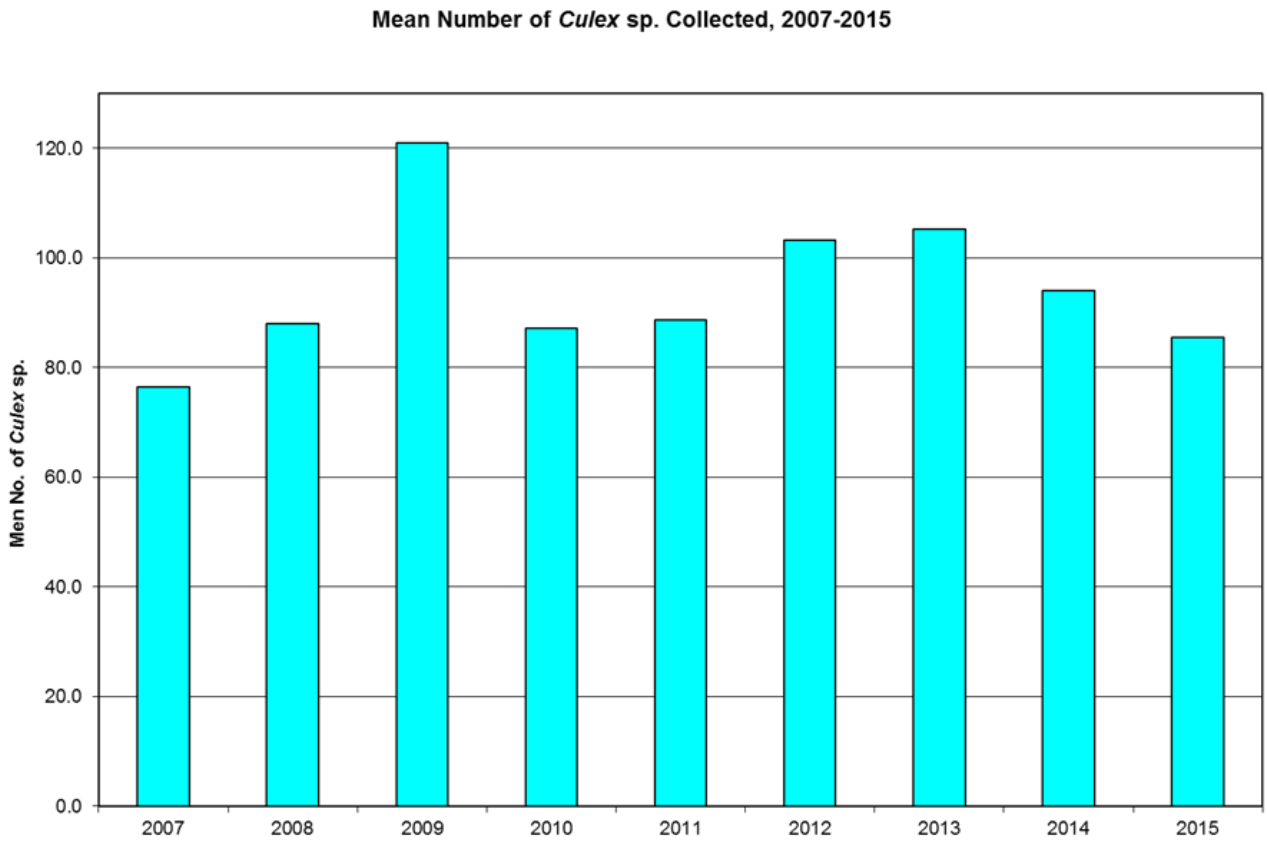


Figure 5. *Culex* Species Mosquito Density Comparison, 2015 vs. 9 Year Mean (2006-2014), Shelby County, TN.

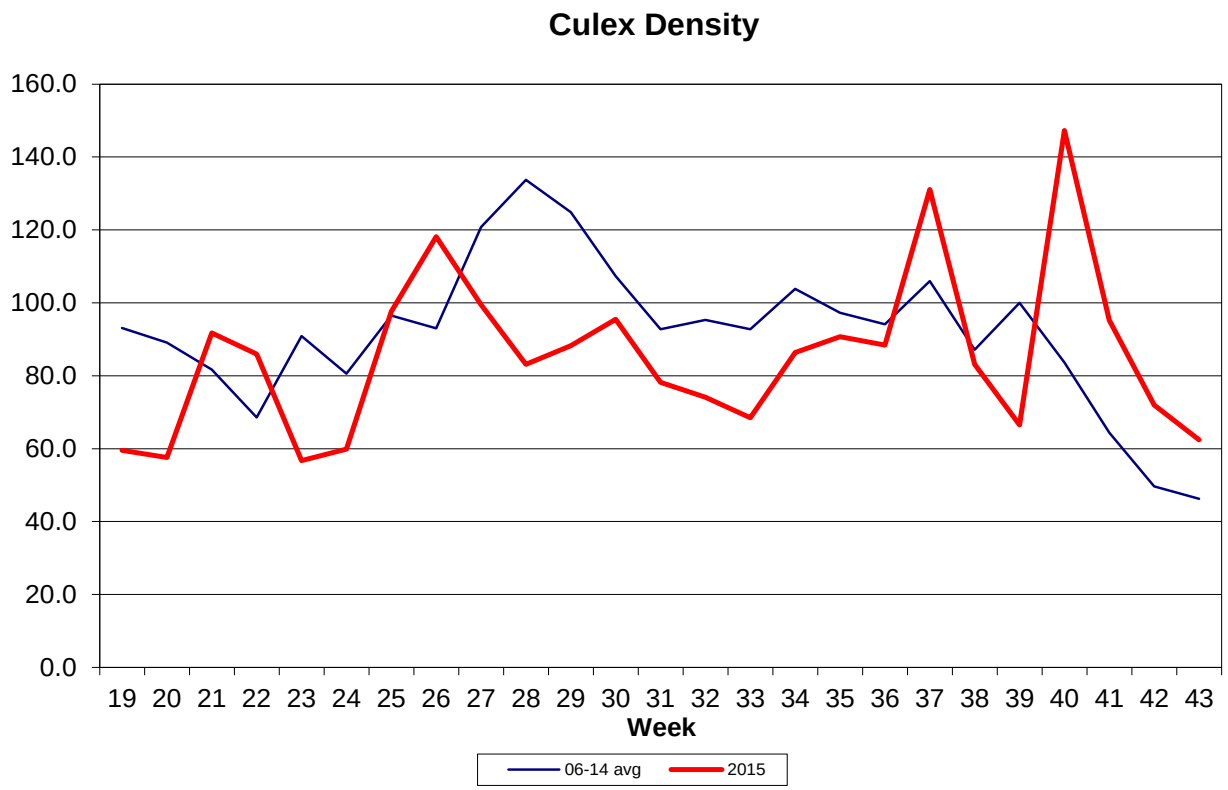
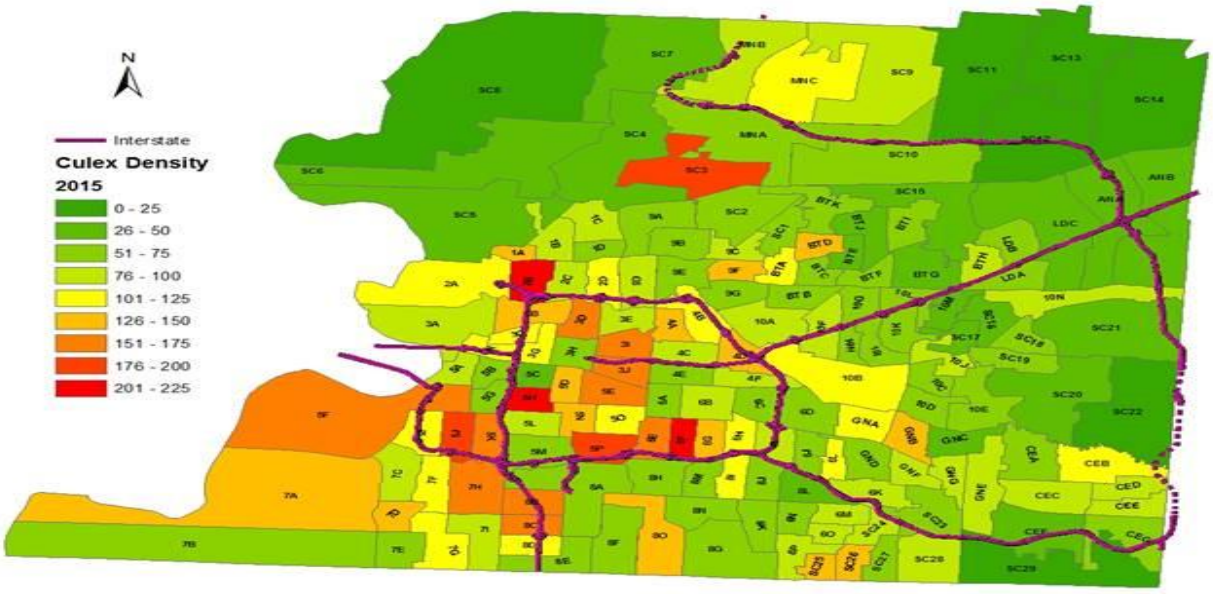


Figure 6. *Culex* Species Mean Mosquito Density by Operational Zone, Shelby County, TN, 2015



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 2006 to 2015. In 2015, there were 613 positive samples out of a total of 4026 samples tested (15%). This is a slight decrease in the percent positive to total samples tested from the 2014 season where there were 701 positive samples out of a total of 3921 samples (18%).

Figure 7. Total Number of Mosquito Samples Tested and Number of Positive Samples, Shelby County TN, 2006-2015

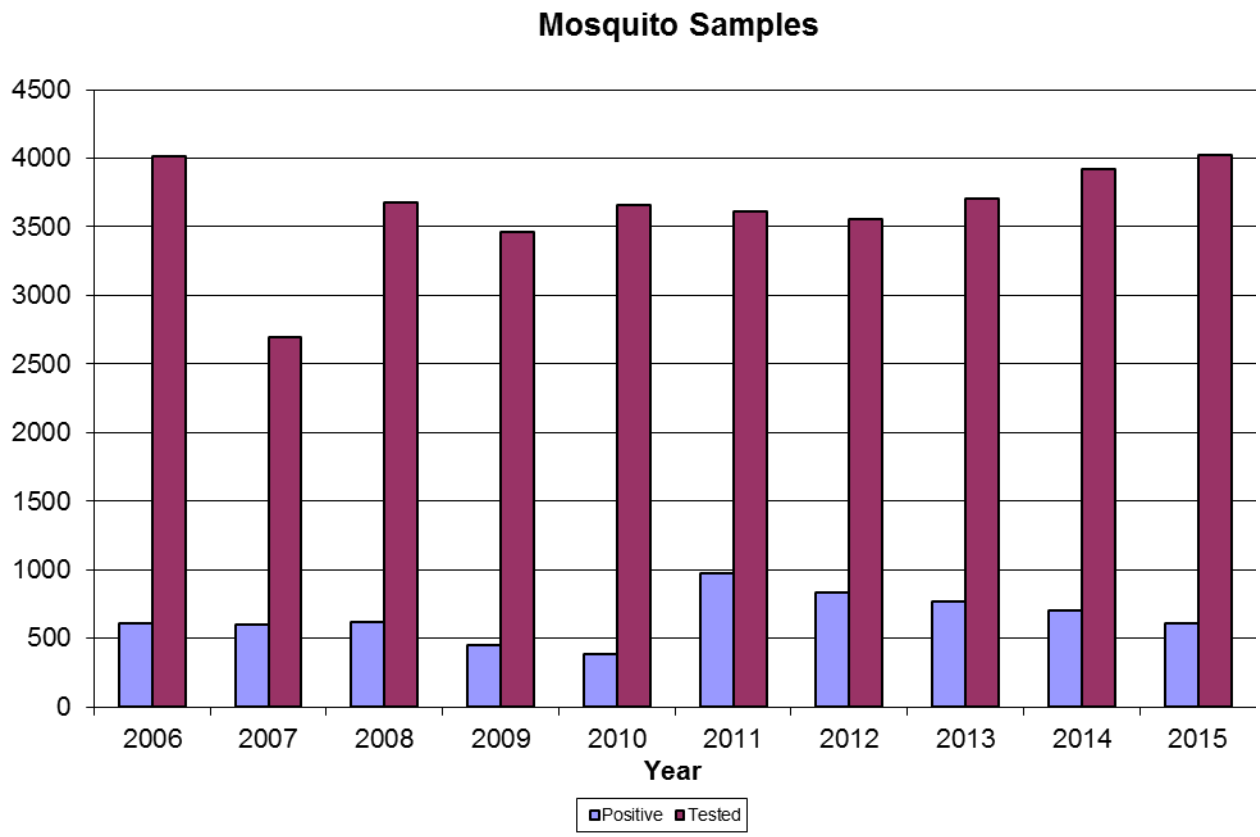


Figure 8 shows the total number of positive pools by week comparing the 2015 season to the mean for the previous nine years. It can be seen that the overall weekly number of positive pools for the 2015 season was noticeably less or equal than the previous nine-year mean (2006-2014) with the exception of the last four testing weeks of 40 through 43. Figure 9 shows the total number of positive pools by operational zone for 2015. Particularly high numbers of positive pools can be seen in pockets throughout the Bartlett area and the surrounding Memphis area adjacent to Bartlett.

Figure 8. Number of Positive Pools by Week, 2015 vs 9 Year Mean (2006-2014)

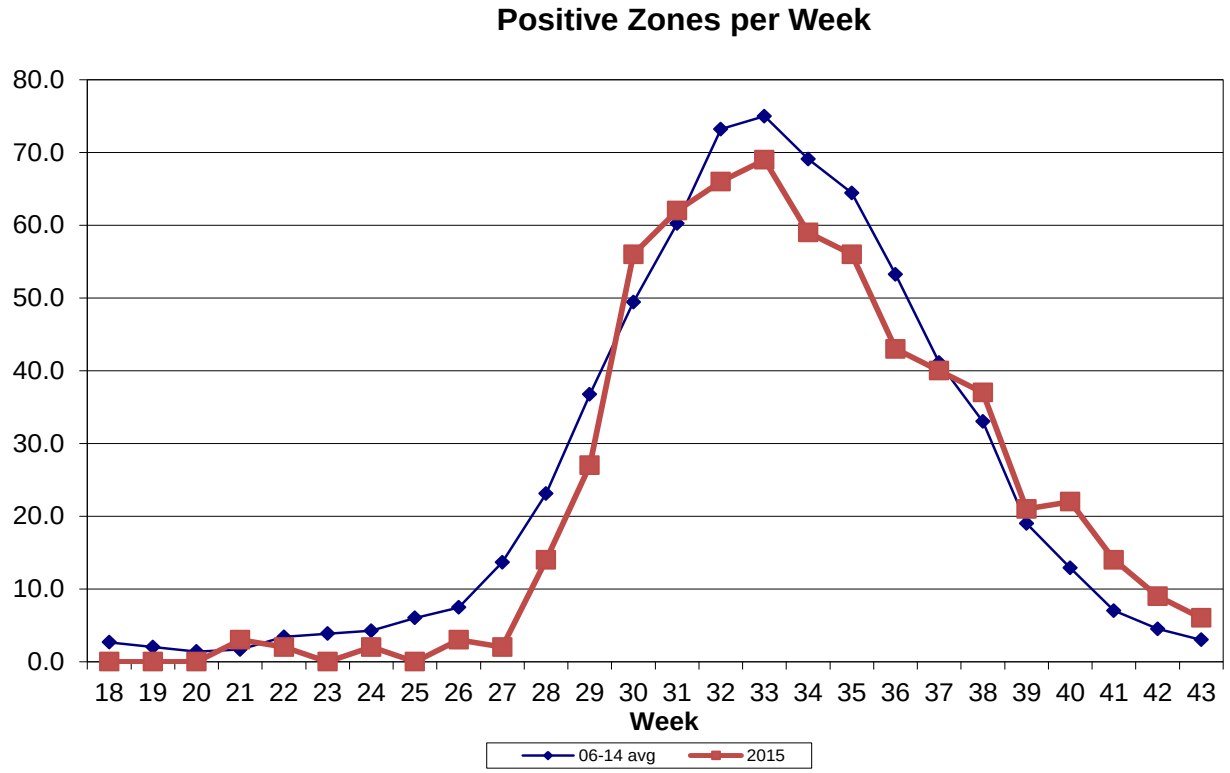
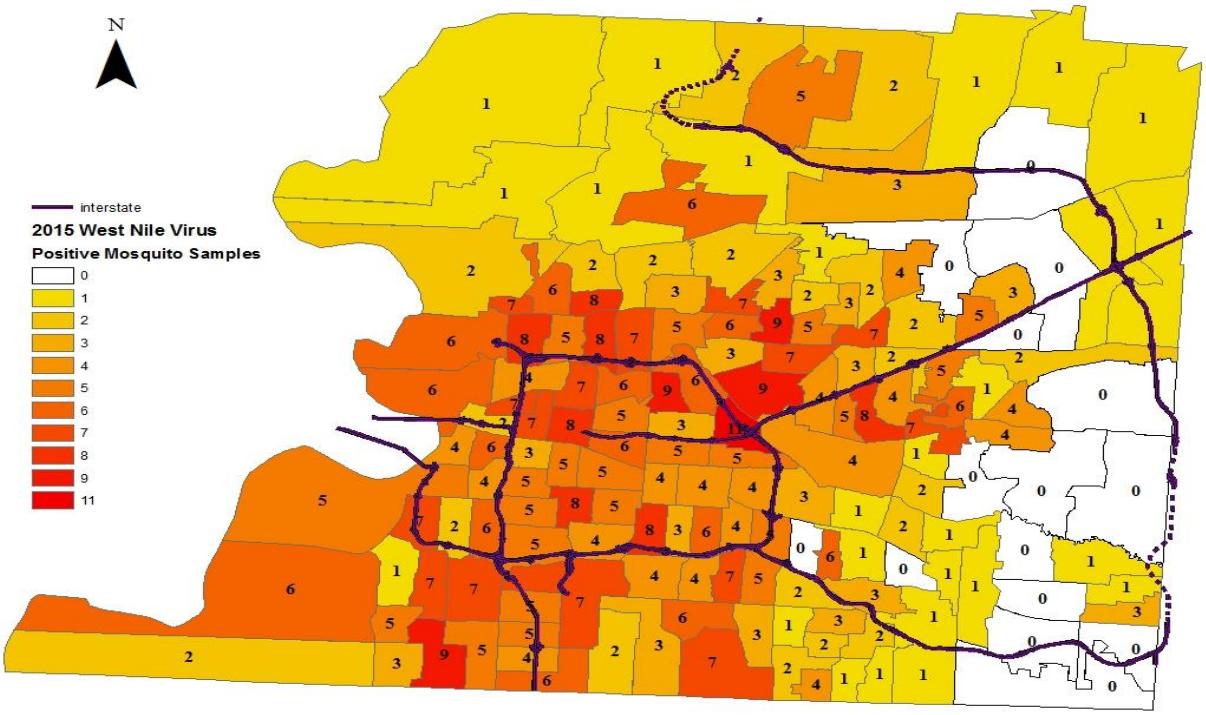


Figure 9. Total Number of Positive Pools by Operational Zone, Shelby County, TN, 2015



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 elapsed a zone initially tests positive to the last week it tests positive. Figure 10 shows the number of zones by their duration of viral persistence for the 2015 season compared to the mean for the previous nine years (2006-2013). For example, in the 2015 season there were seventeen zones that never tested positive for WNV (0 weeks of persistence) compared to 6 zones the previous year (2014) and a mean of about 15 zones in the previous eight seasons. In 2015, there were two zones that had a viral persistence of greater than 20 weeks, as compared to zero zones in 2014. In general, there were many less zones that had long durations of viral persistence in 2015 than there were in the previous nine 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 Bartlett and South Memphis areas

Figure 10. Number of Zones by Duration of WNV Persistence, 2015 vs. 9 Year Mean (2006-2014), Shelby County, TN

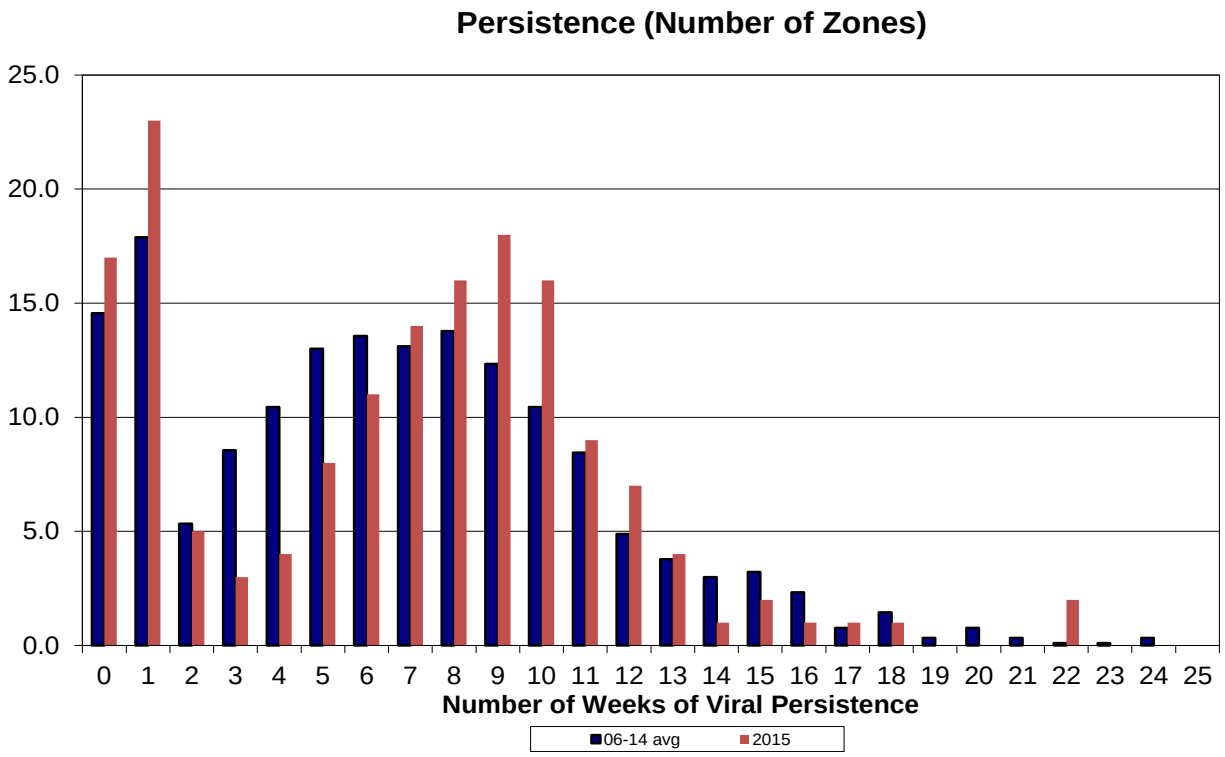
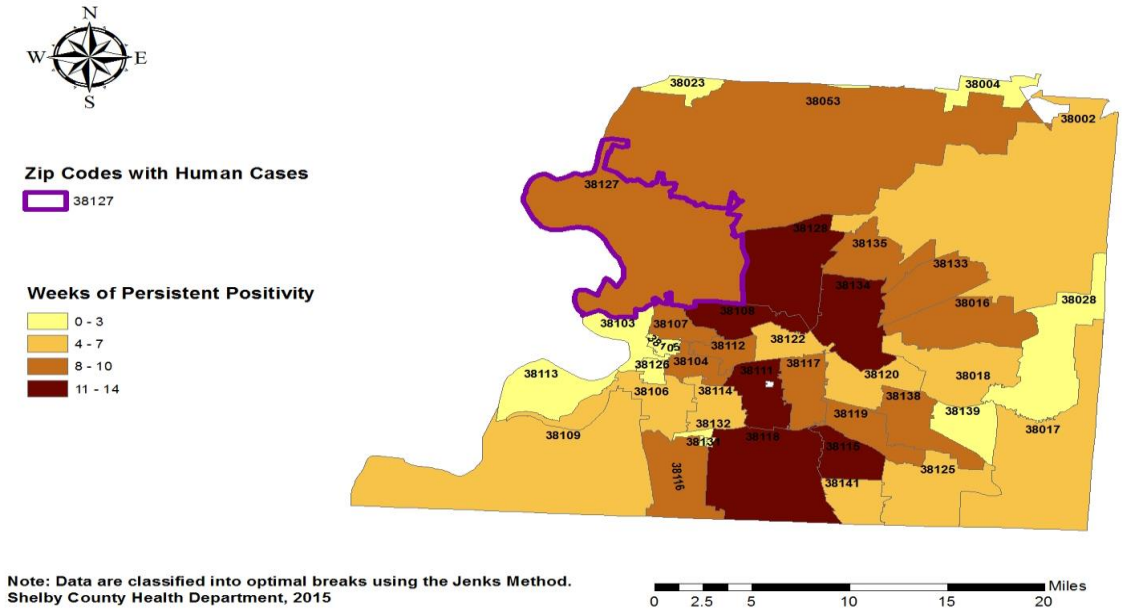


Figure 11. Maximum Number of Weeks of Persistent Positive Pools by Zip Code, Shelby County, TN, 2015



Note: Data are classified into optimal breaks using the Jenks Method.
Shelby County Health Department, 2015

Patterns and Conclusion

For the 2015 season, there was only one nonfatal case, compared with 10 cases and one fatality in 2014 and 9 cases with one fatality in 2013. Overall, the dramatic decrease in the number of human cases in 2015 was seen throughout the nation with a relatively mild summer. Mean *Culex* mosquito density in Shelby County showed another significant decrease in 2015 as compared to the previous season along with the number of positive pools. Like the previous year, the 2015 mosquito season was more compact with very limited mosquito activity for the months of April and May leading to a shorter period with intense activity from June to September. Nevertheless, it is still often generally 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 through the years do appear to coincide to some extent more 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.

To ensure that future human cases of West Nile Virus in Shelby County 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.

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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, 2015

Week	Number of Mosquitoes Collected	Mean Number of *Culex* Mosquitoes per Trap	Number of Pools Tested	Number of Positive Pools	Percentage of Positive Pools
17	25907	162.9	133	0	0.0
18	19370	122.6	128	0	0.0
19	96t38	59.5	148	0	0.0
20	9270	57.6	127	0	0.0
21	13932	91.7	151	3	2.0
22	14009	85.9	160	2	1.3
23	9234	56.7	152	0	0.0
24	9704	59.9	145	2	1.4
25	15915	97.6	155	0	0.0
26	18826	117.7	162	3	1.9
27	16211	99.5	152	2	1.3
28	13552	83.1	146	14	9.6
29	14107	88.2	148	27	18.2
30	15478	95.5	148	56	37.8
31	12531	77.8	150	62	41.3
32	11938	74.1	155	66	42.6
33	11026	68.5	151	69	45.7
34	13903	86.4	157	59	37.6
35	13972	90.7	147	56	38.1
36	13354	88.4	143	43	30.0
37	20969	131.1	150	40	26.7
38	13298	83.1	150	37	24.7
39	10369	66.5	150	21	14.0
40	23965	147.3	160	22	13.8
41	15421	95.2	158	14	8.9
42	11447	72.0	152	9	5.9
43	9988	62.4	148	6	4.1

Table B2. Mean Number of *Culex* Mosquitoes per Week, Shelby County, TN, 2007-2015

Week	2007	2008	2009	2010	2011	2012	2013	2014	2015
19	64.9	124.0	123.7	44.7	83.7	132.8	194.1	11.1	59.5
20	39.6	86.8	73.7	112.5	76.3	109.6	134.5	58.8	57.6
21	76.8	93.8	97.3	85.9	90.5	77.6	100.4	26.3	91.7
22	54.0	105.8	85.1	39.1	66.6	62.8	75.3	38.7	85.9
23	54.2	43.7	73.5	55.0	47.4	246.1	133.3	64.7	56.7
24	139.1	46.5	72.2	74.5	65.9	81.6	78.2	87.3	59.9
25	138.1	63.9	113.6	92.8	72.7	113.4	112.5	82.6	97.6
26	92.6	67.0	87.0	134.5	100.4	99.6	100.8	104.4	118.1
27	77.4	158.6	164.5	149.4	112.1	146.2	98.1	129.7	99.5
28	73.8	93.5	210.6	237.7	138.4	139.7	147.0	131.9	83.1
29	82.9	129.8	236.7	62.6	139.4	100.9	171.0	147.6	88.2
30	60.0	103.1	106.8	97.2	138.0	85.8	129.1	156.8	95.5
31	53.4	81.1	127.9	73.3	92.0	73.1	127.1	153.3	78.2
32	81.7	73.6	152.9	71.1	89.4	94.6	120.4	117.3	74.1
33	45.3	73.7	137.2	68.2	141.6	73.1	115.7	105.5	68.5
34	53.3	89.5	191.5	62.5	94.0	89.6	122.4	165.3	86.4
35	66.3	101.6	147.4	66.1	99.7	87.4	87.9	143.3	90.7
36	80.6	87.3	151.2	106.6	85.2	106.0	72.6	102.3	88.4
37	73.6	152.3	171.2	118.1	88.9	114.3	87.0	107.3	131.1
38	94.1	66.4	92.0	126.1	113.4	91.7	99.7	78.0	83.1
39	100.1	98.6	74.9	95.2	101.8	143.3	120.7	121.0	66.5
40	66.4	81.5	121.7	51.5	62.5	108.5	97.1	130.0	147.3
41	88.6	51.9	43.1	65.3	53.9	63.2	65.3	72.6	95.2
42	--	86.8	--	46.1	17.7	55.5	78.8	49.7	72.0
43	--	38.8	50	42.1	45.7	105.6	36.2	29.5	62.4