King County West Nile Virus Surveillance Report 2007

Public Health
Seattle & King County

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Public Health—Seattle & King County
401 5th Ave, Ste 1100
http://www.metrokc.gov/health/westnile

Introduction

West Nile virus (WNV) is an arbovirus which has the potential to be a debilitating disease. Most people infected with the disease are asymptomatic. Of those that experience symptoms, their illness is often mild and may include fever, headache, fatigue, loss of appetite, and muscle aches. Approximately 1 in 150 people infected with WNV will develop a more severe illness including severe headaches, neck stiffness, convulsions or coma, decreased level of alertness, muscle weakness, tremors, paralysis, and even death.

Birds are the natural reservoir of WNV. The virus is amplified as mosquitoes feed on infected birds and transmit it to other birds. Humans and other mammals enter the disease cycle only when infected mosquitoes feed on them.

West Nile virus was first detected in North America in 1999 in New York City. Since its arrival, WNV has spread in all directions across the continent. According to the Centers for Disease Control, WNV has resulted in 10,879 cases of neurological illness and killed 1,049 people in the United States as of November 2, 2007.

West Nile virus has been detected intermittently at low levels in parts of Washington State since 2002. The year 2006 marked the first year that humans were believed to have acquired WNV infections within the state of Washington. That same year, the first signs of WNV were detected within King County, where Public Health—Seattle & King County (Public Health) has been monitoring since 2001, with six birds and 1 horse testing positive for the virus. Because of this we entered the 2007 season expecting earlier and more prolonged WNV activity, with the possibility of human cases or even a significant outbreak. In 2007, an enhanced WNV surveillance program was implemented in preparation for more intense levels of infection in the county.

Bird Mortality Surveillance

Corvids, such as crows, jays, ravens, and magpies, are especially sensitive to WNV and commonly die as a result of infection. Several studies [Mostashari et al, 2003; Johnson et al, 2006)] have suggested that bird mortalities may be useful in predicting human WNV infections. In response to this observation, Public Health solicits and receives online and telephone reports from the public about observed bird deaths in King County throughout the year. During the WNV season (late June through October), a selection of birds are collected for WNV testing based on bird type, condition, and worker availability. In order for a bird to be selected for testing it must be freshly dead and in good condition. Corvids are preferentially submitted for testing, although occasionally other birds such as raptors and robins are also submitted for WNV testing. Through an interagency cooperative agreement, dead birds reported to Public Health meeting the criteria for avian influenza dead bird reporting (as determined by Washington State Department of Agriculture (WSDA) for domestic poultry and Washington Department of Fish & Wildlife (WDFW) for wild birds and waterfowl) are referred to the appropriate agency. Birds to be tested for WNV are shipped to the Washington Animal Disease Diagnostic Laboratory (WADDL), in cooperation with the DOH, for West Nile virus testing. Results of WNV testing are received on a weekly basis from the Washington State Department of Health. There is approximately a two week lag time between submission and receipt of results, although the lag is reduced to one week if a sample tests positive. In addition to testing, the locations of all bird mortality reports are mapped on a weekly basis using ArcMap 9.2 in order to identify unusual clustering of bird deaths. Clustering may signify the beginning of a WNV outbreak among the birds and indicates the need for more intense sampling and testing in the area if WNV has not yet been detected through other means.

In 2007, we received 2,379 bird mortality reports from the public reporting 2,798 dead birds. The number of bird mortality reports exceeded that of 2006 by 11%, but the number of bird mortality reports tends to peak biannually **(**Figure 1). Bird mortality reporting peaked during the month of June with 744 dead birds being sighted (Figure 2). Seventy-six percent of bird mortalities reported were crows which does not appear to be unusual compared to previous years (Figures 3, 4). When bird mortality reports were mapped by zip code, the greatest number of bird morality reports came from North Seattle, Lake Forest Park, Seward Park, and areas of Shoreline, Kenmore, Federal Way, and Kirkland (Figure 5). No large clusters of bird mortalities were observed when bird reports were examined on a weekly or tri-weekly basis. Ten reports of dead birds were referred to WSDA or WDFW for avian influenza follow up.

In anticipation of a possible WNV outbreak in 2007, we began bird testing in May, two months earlier than 2006. One-hundred twenty five birds were submitted for testing as compared to 97 in 2006 (a 29% increase). No birds tested positive for WNV. Ninety-four percent of the birds submitted for testing were American Crows (*Corvus brachyrhynchos*). Other birds submitted were Stellar's Jays, an American Robin, a barn owl, a sharp-shinned hawk, and a European Starling. Nearly 47% of the birds submitted were collected in Seattle. Between one and twelve birds were collected from 24 other cities throughout King County (Figure 5).

Future Directions

It is anticipated that there will be some changes in the bird mortality surveillance in the 2008 WNV season. Due to reductions in budget, we expect to collect oral swabs for sample submission rather than collecting and shipping the entire bird carcass for testing. We also expect to have acquired some software to do statistical analyses of the spatial distribution of bird deaths to determine if there are unusual numbers of deaths occurring in a specific area.

We will continue to assist WSDA and WDFW by referring calls about dead birds to the appropriate agency in 2008. Based on our experiences in 2007, we will modify our dead bird intake form and protocols for 2008 to better capture the information to determine whether a bird is eligible for reference to WSDA or WDFW for avian influenza surveillance.

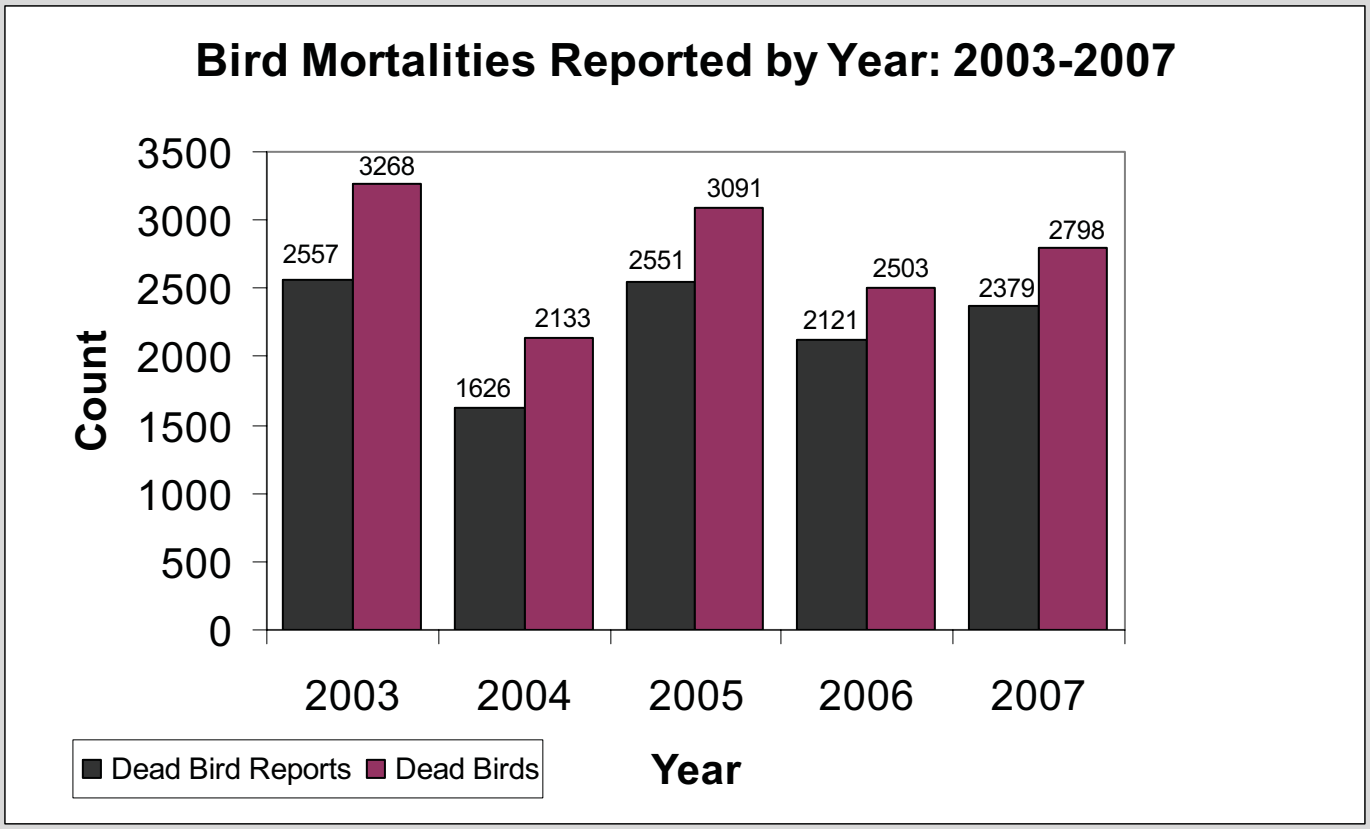

Figure 1. Count of bird mortality reports and the number of bird mortalities associated with these reports by year.

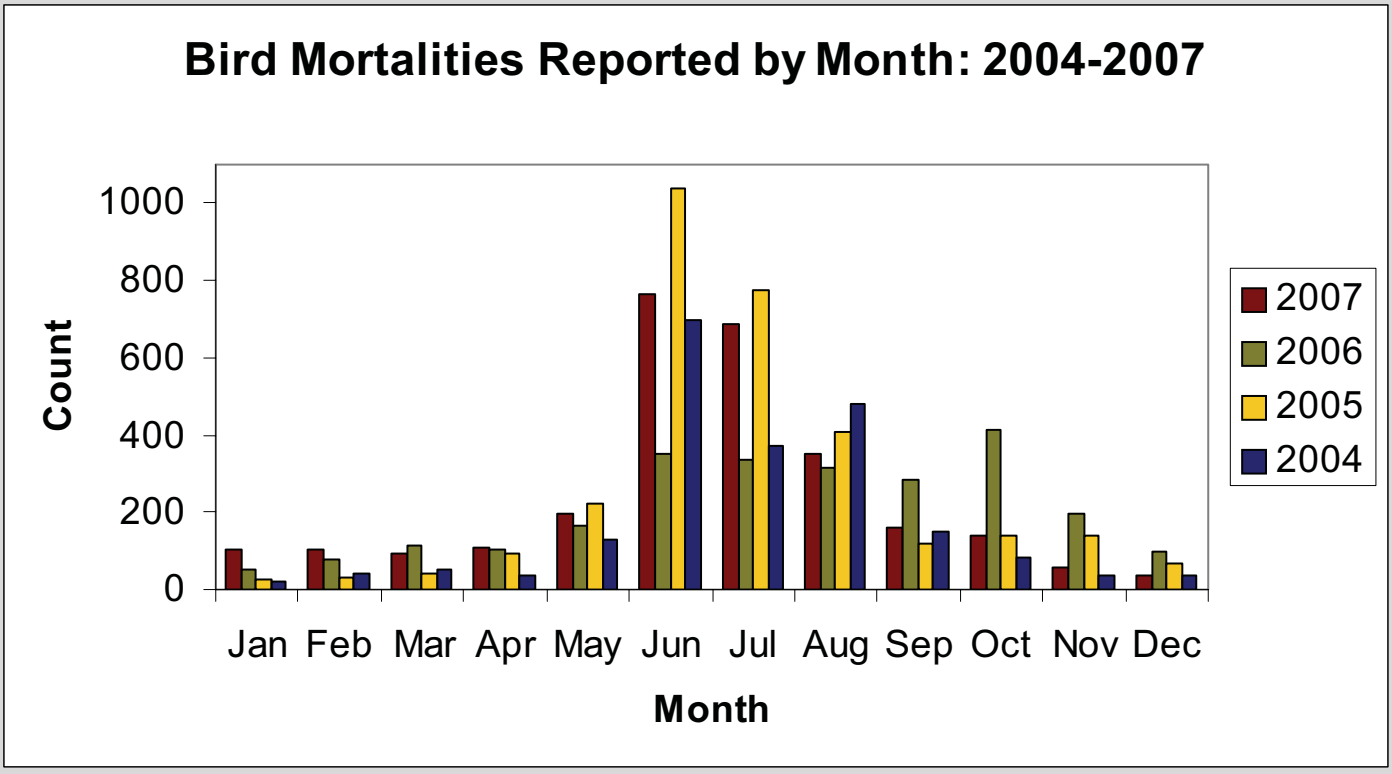

Figure 2. Count of bird mortalities reported to Public Health each month from 2004-2007. Reports of bird mortalities appear to peak in June each year.

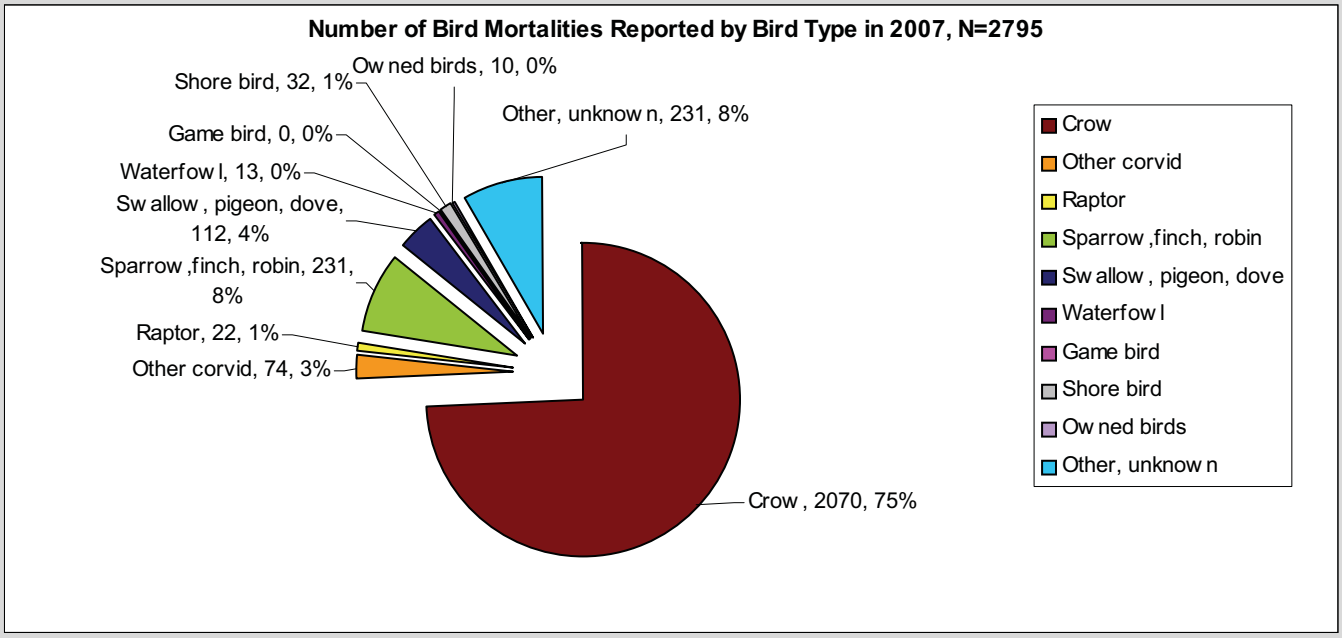

Figure 3. Distribution of bird mortalities by bird type. Three-quarters of the bird mortalities reported are crows.

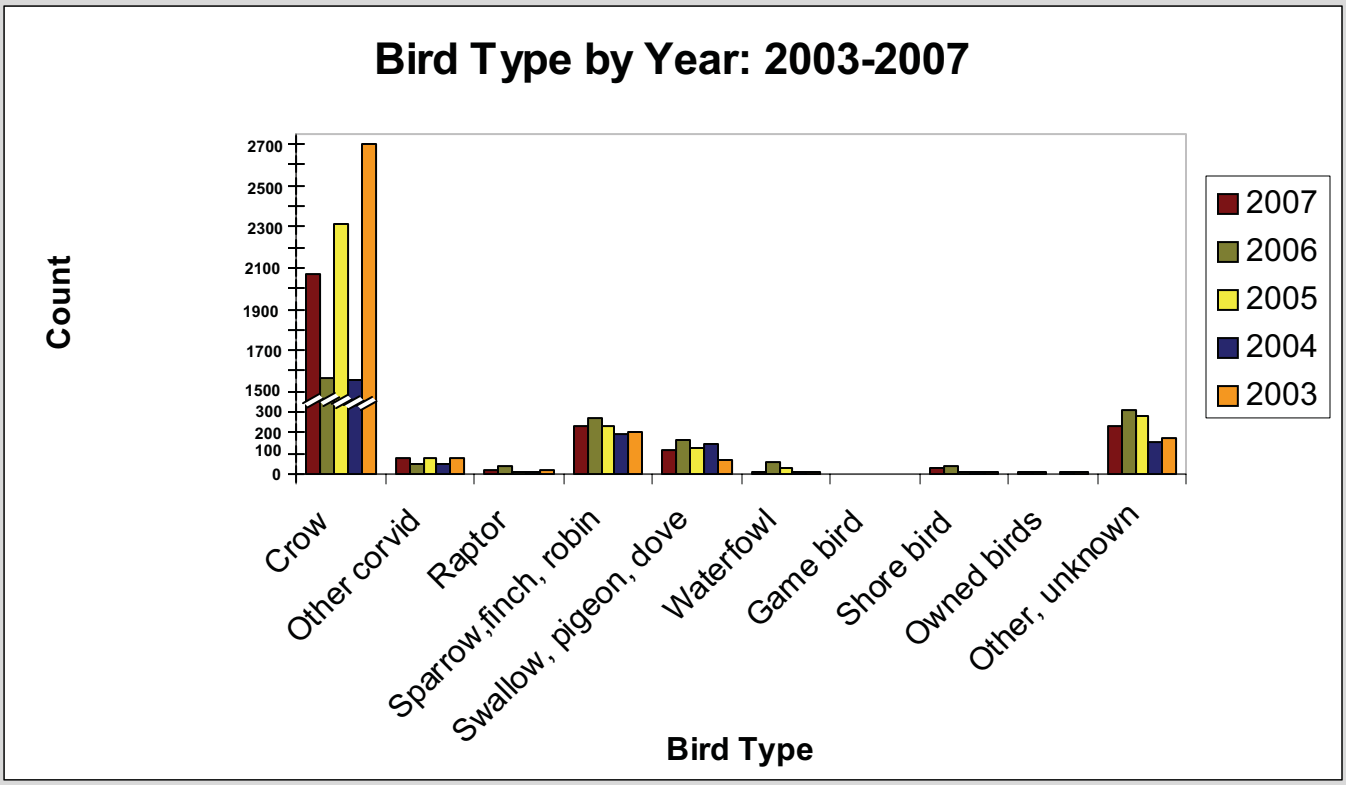

Figure 4. Bird mortalities by bird type between 2003 and 2007. Many more crows than any other bird type were reported each year, although the margin of this majority seems to alternate every other year.

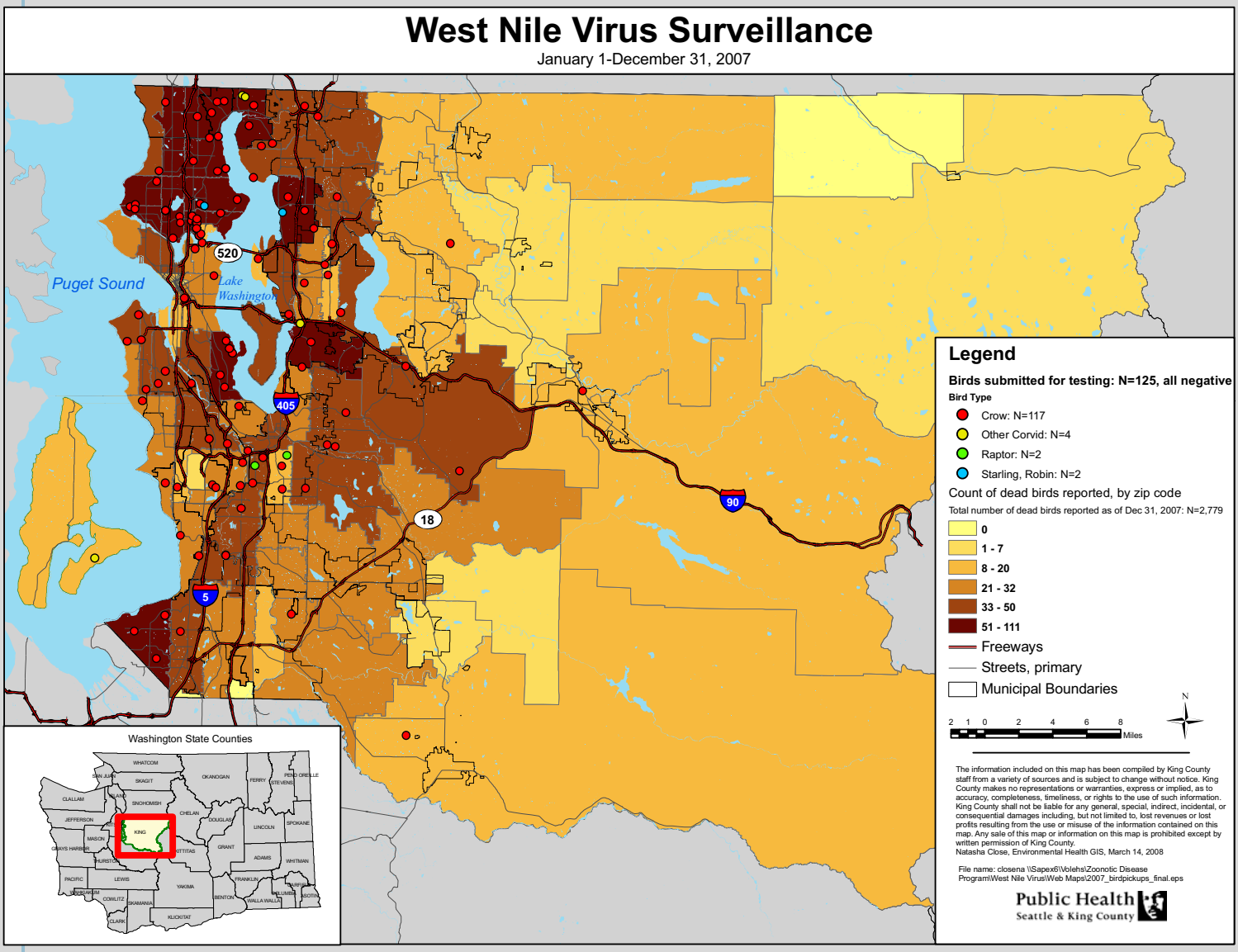

Figure 5. Map of bird mortalities reported to Public Health in 2007, by zip code. The location of birds collected and submitted for testing are marked by the points on the map (N=125). Colors of the points depict the bird type. All birds tested negative.

Mosquito Surveillance

The 2007 mosquito surveillance program involved collecting adult mosquitoes in Encephalitis Vector Survey (EVS) traps with dry ice from sites throughout King County (Figure 6) at regular time intervals during the summer months. Mosquitoes are sent to DOH for species identification and then on to the Center for Health Promotion and Preventive Medicine West (CHPPM West) located in Ft. Lewis, WA for WNV testing. Species identification allows Public Health to assess the presence of vector species in an area and it allows resources for testing to be directed toward those species that have the potential to transmit WNV to humans (*Culex pipiens* and *Culex tarsalis*). Once species identification and testing are completed, the results are sent back to Public Health where they are entered into a database, monitored, and mapped periodically. Mosquito surveillance allows us to determine the degree of West Nile virus infection in the mosquitoes in the area which in turn dictates the level of risk for the human inhabitants of King County.

We were able to greatly increase surveillance in terms of number of trapping sites, geographical representativeness, and frequency of trapping compared to 2006 by hiring a West Nile virus surveillance intern to conduct mosquito trapping and prepare specimens for shipping.

In addition to the seasonal intern, Public Health entered into a partnership with the Seattle Public Utilities Department (SPU) for mosquito surveillance activities. SPU has been conducting research on the effectiveness and fate of larvicides applied to catch basins. As part of this research project, SPU hired an environmental consultant firm to conduct adult mosquito trapping at geographically distributed sites within the city of Seattle. This also allowed Public Health staff to concentrate trapping in other cities and unincorporated King County.

The table below shows the breakdown of trapping results for the city of Seattle and the remainder of King County.

	# Trapping Events	# Mosquito Pools (with >0 mosquitoes)	# Mosquitoes	# Pools of Vector Species Tested	% of Pools Tested
City of Seattle	268	579	7801	181	31.3
King County outside Seattle	145	324	2142	28	8.6
Totals	413	903	9943	209	23.1

No mosquito pools tested positive for WNV in 2007. An unexpected finding was that the average total number of mosquitoes collected in each trapping event was significantly larger at sites within the city of Seattle as compared to all other King County sites (T test, $p<0.05$, Figures 7, 8). This is despite the efforts of SPU to reduce mosquito populations by larviciding all catch basins within the city of Seattle at the beginning of the WNV season. In addition, a significantly larger percentage of the *Cx. pipiens* were collected per trapping event at trapping sites within the city of Seattle as compared to sites outside the city (T test, $p<0.05$). The species diversity, as measured by Shannon's Diversity Index, was significantly lower at trapping sites within the city of Seattle as opposed to KC sites outside of Seattle (T Test, $p<0.05$).

Conducting species identification allows us to have a better understanding of mosquito ecology in our area which has diverse topography. Seventeen species of mosquitoes were identified in King County in 2007. It is believed that the variation in abundance and species collected at different trapping sites is due to a number of factors. Some potential associations are: overall setting of trapping site, availability of preferred larval habitat within flight range, and availability of the preferred host during the mosquitoes' active periods. These inferences are based on the knowledge that different mosquito species vary in preferred larval habitat, active periods, and preferred hosts.

The diversity of species progressively drops throughout the summer months (Figure 9). This change in diversity is dramatically more noticeable at sites outside of the city of Seattle than within the city. This may be tied to climate factors both on the actual night of trapping and throughout the season; however, the level of species diversity does not appear to be directly correlated to the weekly average temperature nor the weekly precipitation as reported at

Sea-Tac International Airport (Figure 9). The natural life cycle of different species of mosquitoes may also dictate the time of year that they are most abundant, which would influence the species diversity seen throughout the season.

Future Directions

2007 was the first year systematic mosquito trapping was conducted in both Seattle and King County outside of Seattle. An unusually high volume and frequency of precipitation occurred during July and September, which are usually relatively dry. Additional years of data are needed to determine how mosquito abundance and species diversity vary with weather patterns, development and land use changes, and mosquito control activities. Better understanding of trapping sites and trapping conditions, consistency in trapping protocols, and more experience on the part of personnel will minimize the influence of iatrogenic factors.

Ongoing mosquito surveillance is a fundamental public health tool in the control of vector-borne diseases, and can be expected to increase in importance with the influences of climate change and global warming. In response to this need, Seattle Public Utilities has agreed to repeat their mosquito trapping scheme in 2008. Public Health plans to trap mosquitoes again in 2008, using a more systematic approach so that the same sites are visited on a regular basis.

A look at the mosquito species in King County

Recently a project was undertaken to create accurate logs of the mosquito species that have been identified throughout Washington State over the past several years (Sames et al, 2007). Using historical records and mosquito collections dating as early as 1917 to as recent as 2005, 29 species of mosquitoes have been identified in King County. Seventeen species of mosquitoes were identified in King County during the course of the 2007 mosquito surveillance season.

Table 1. Comparison of mosquito species identified during 2007 mosquito surveillance (N=17[a]) to historical log of mosquito species identified in King County (N=29).

Mosquito Species identified historically in King County	Mosquito Species identified in 2007	Mosquito Species identified historically in King County	Mosquito Species identified in 2007
Ae. cinereus	X	*Cx. tarsalis*	X
Ae, vexans	X	*Cx. territans*	X
An. freeborni	X	*Oc. aboriginis*	X
An. punctipennis	X	*Oc. aloponoium*	
Cq. perturbans	X	*Oc. communis*	
Cs. impatiens		*Oc. dorsalis*	
Cs. incidens	X	*Oc. excrucians*	
Cs. inornata	X	*Oc. fitchii*	X
Cs. minnesotae	X	*Oc. hexodontus*	
Cs. morsitans		*Oc. increpitus*	X
Cs. particeps	X	*Oc. japonicus ja-ponicus*	
Cx. apicalis		*Oc. pullatus*	
Cx. boharii		*Oc. sierrensis*	X
Cx. pipiens	X	*Oc. sticticus*	X
Cx. stigmatasoma			

[a]Some mosquitoes were not identified down to the species level.

Several of the species that have been identified in King County, either historically or currently, are potential primary and bridge vectors for diseases such as Eastern Equine encephalitis (*Ae. vexans*, *Cq, perturbans*), St. Louis encephalitis (*Cx. pipiens*, *Cx. tarsalis*), West Nile virus (*Cx. pipiens*, *Cx. tarsalis*, *Oc. japonicus*, *Ae. vexans*), La Crosse encephalitis (*Cs. inornata*, *Oc. communis*, *Oc. dorsalis*, *Oc. japonicus*), dog heartworm (*Oc. sierrensis*), and malaria (*An. freeborni*, *An. punctipennis*)

Historically, vector-borne diseases have been rare in King County, possibly because conditions have not been appropriate for the necessary vectors to thrive. With changes in the climate and other environmental conditions, mosquito population dynamics may change such that they increase the potential for vector-borne disease transmission in King County. Therefore it will important in the coming years to continue monitoring the abundance and composition of the mosquito populations in the area.

Reference: Sames W, Duffy A, Maloney FA, Townzen JS, Brauner JM, Mchugh CP, Lilja J. 2007. Distribution of mosquitoes in Washington State. *Journal of the American Mosquito Control Association*. 23:442-448.

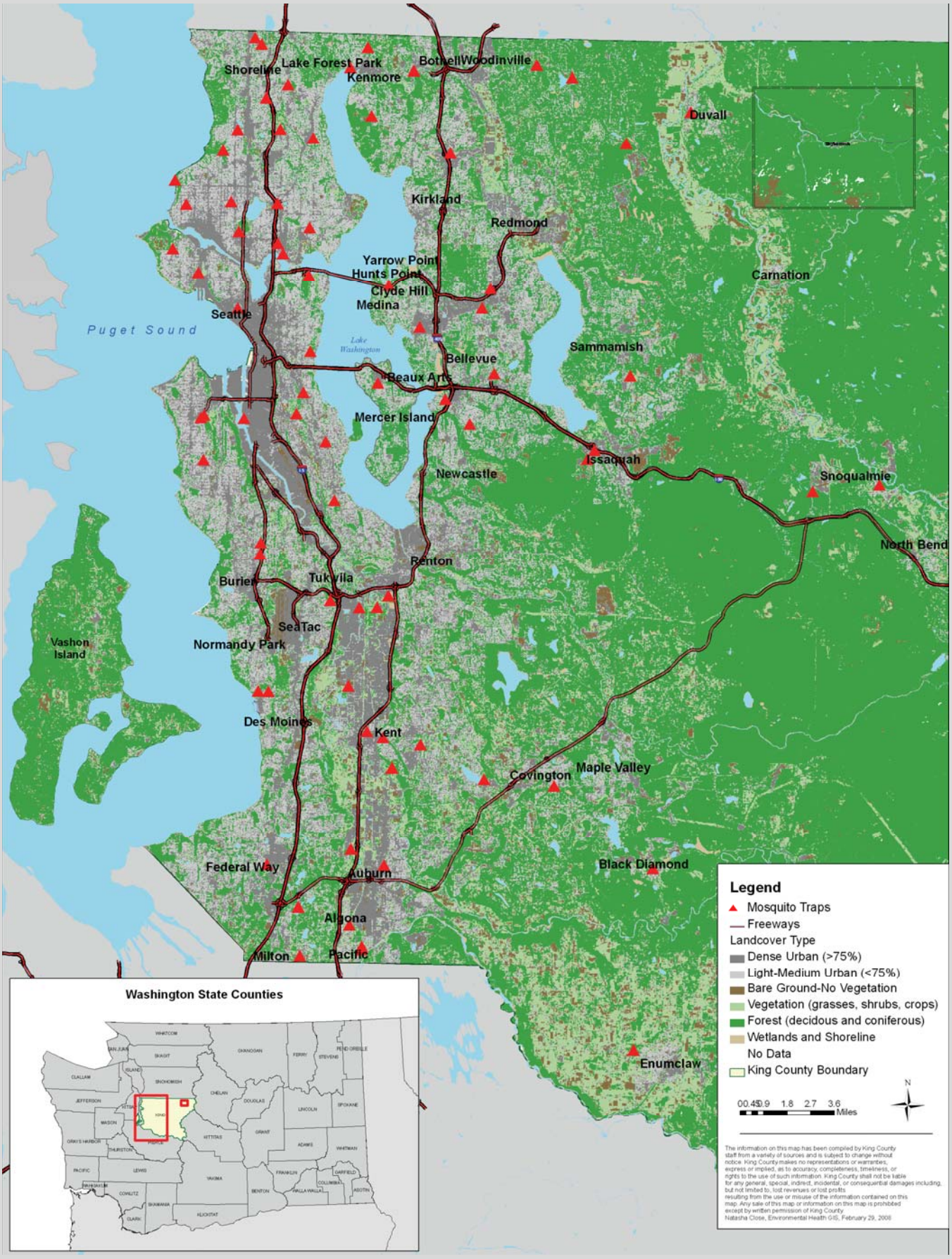

Figure 6. Mosquito trap locations. Coloration of the map indicates the landcover type.

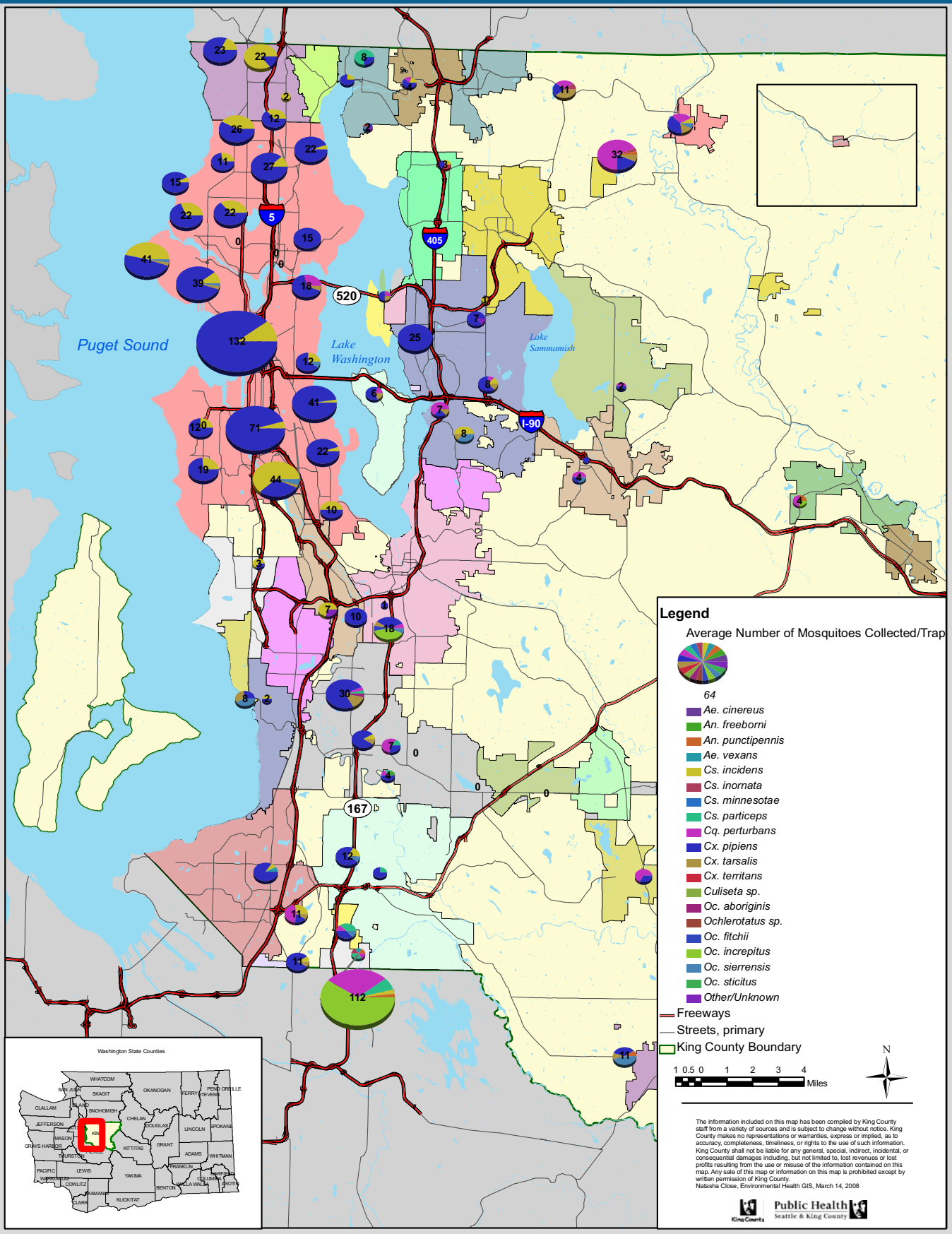

Figure 7. Map of trapping sites in King County with the pie charts depicting the average abundance of mosquitoes per trap night and species distribution.

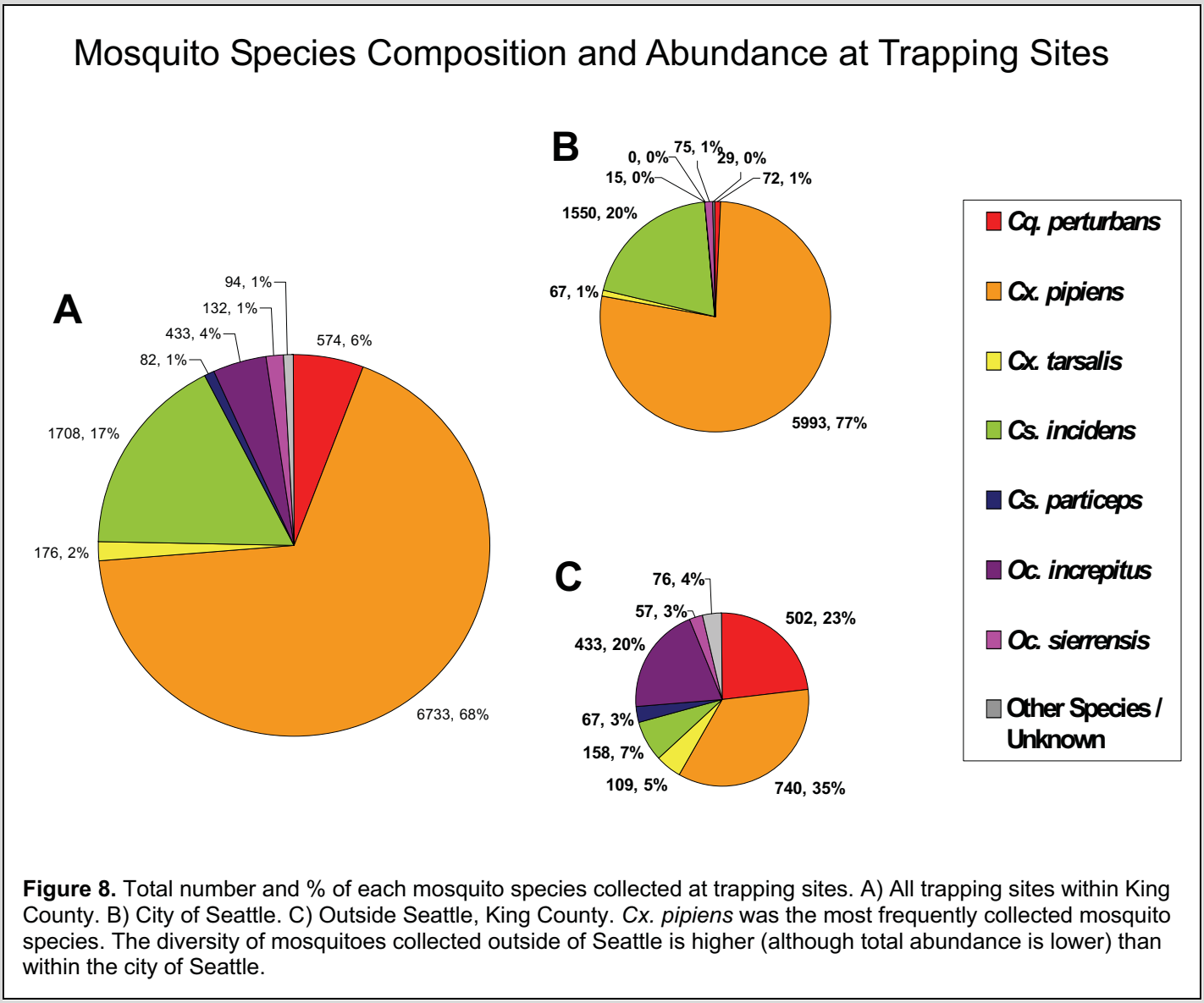

Figure 8. Total number and % of each mosquito species collected at trapping sites. A) All trapping sites within King County. B) City of Seattle. C) Outside Seattle, King County. *Cx. pipiens* was the most frequently collected mosquito species. The diversity of mosquitoes collected outside of Seattle is higher (although total abundance is lower) than within the city of Seattle.

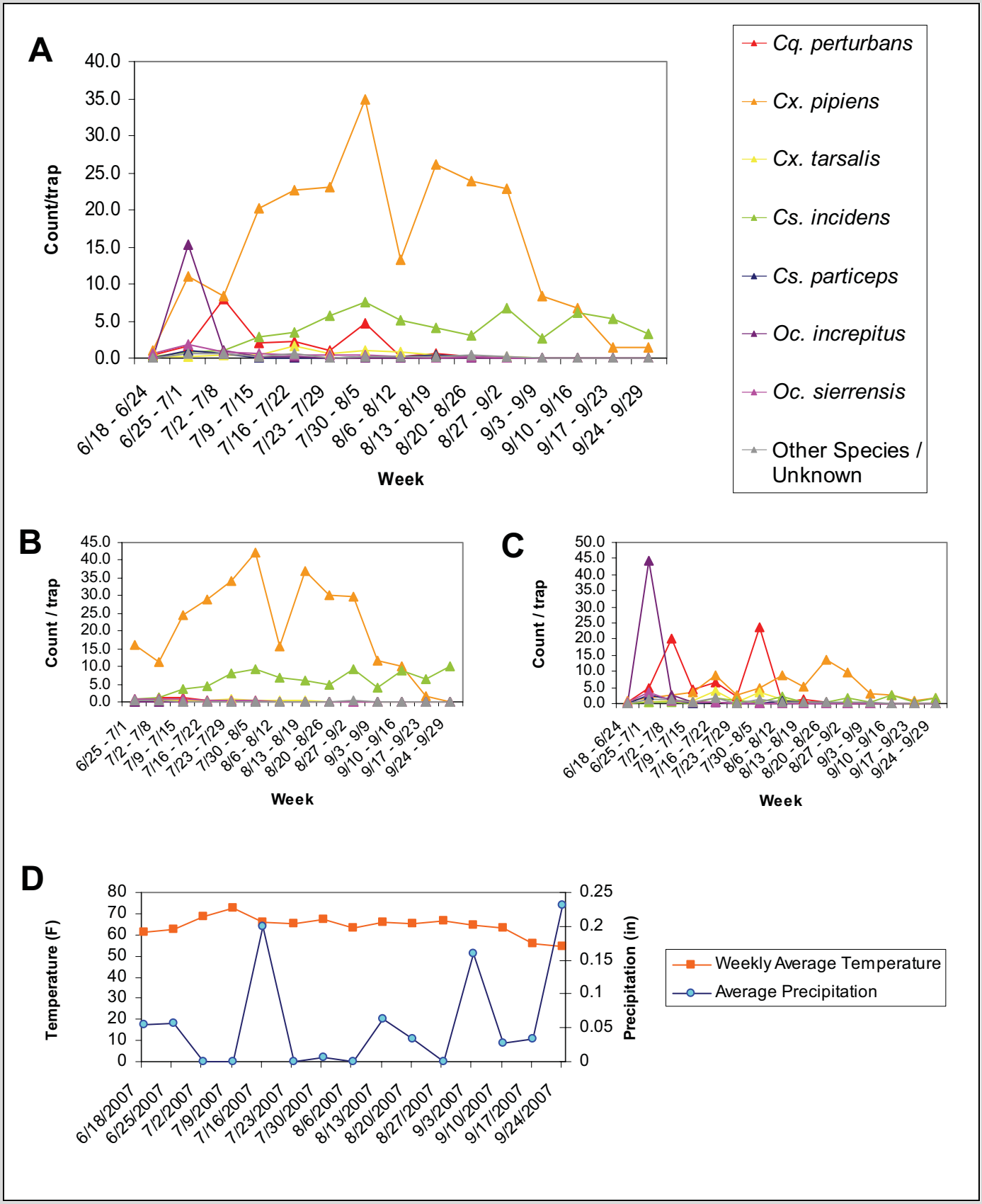

Figure 9. Average number of each mosquito species collected per trap during the 2007 summer season. A) All trapping sites within King County. B) City of Seattle. C) Outside Seattle, King County. D) Weekly precipitation and weekly average temperature.

Other Surveillance

Non-human Mammal Surveillance

In coordination with veterinary care providers in King County, we monitor non-human mammals for infection with West Nile virus. Five horses were tested for the presence of a WNV infection; however, all tested negative for the virus. No cases of non-human mammalian WNV infection were detected in King County in 2007.

Human Surveillance

West Nile virus is a reportable condition in Washington State. No cases of locally-acquired WNV infection were reported in King County in 2007. There was one King County resident that had a confirmed WNV infection and one King County resident that had a possible WNV infection in 2007; both were associated with travel outside of Washington State.

Appendix A:
Washington State 2007 Surveillance Summary

Table 1. Positive West Nile virus surveillance results in Washington State, 2007.

	Bird	Mosquito Pools	Horse or Other Mammal	Human[a]	Total
Yakima	1	0	9	0	10
Washington State	1	0	9	0	10

[a]Human case count refers only to West Nile virus infections acquired locally.

Appendix B:
Public Health Surveillance Staff, 2007

Sharon G. Hopkins, DVM, MPH……Public Health Veterinarian

Leah Helms, RS……West Nile Virus Coordinator

Natasha Close, MPH……..Epidemiologist

Eric Coker……..West Nile Virus Surveillance Intern

Kate Sawatzki…….Seasonal Temp

Michelle Pederson…….Administrative Lead