Toronto and Region Conservation Authority

West Nile Virus Mosquito Monitoring Report - 2022

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SUMMARY

Toronto and Region Conservation Authority (TRCA) established the West Nile Virus (WNV) Larval Mosquito Surveillance and Monitoring Program in 2003. The program has a three-pronged approach, which includes larval mosquito monitoring, prevention through education and communication, and collaboration with regional public health units. The objective of the program is to identify WNV mosquito hotspots, take appropriate intervention measures to reduce risk for people, and ultimately to protect our wetlands.

Traditionally, wetlands are considered mosquito-friendly habitats, therefore posing serious WNV threats. However, TRCA's long-term monitoring data have shown that wetlands generally do not support large mosquito vector populations. Nonetheless, occasionally hotspots in wetlands have been detected through our surveillance program. TRCA takes appropriate control measures to eliminate mosquito larvae from these hotspots. A WNV mosquito hotspot is recognized when > 30 larval mosquitoes of a vector species are collected at a site. Mosquitoes can only carry WNV after biting an infected bird. Mosquito larvae do not feed on blood, thus do not carry the virus. When a site is identified as a hotspot, it simply indicates the presence of vector species which could potentially spread WNV after they emerge as adult mosquitoes, not the presence of the virus itself.

Research results suggest that two mosquito species, *Culex pipiens* and *Culex restuans*, are primarily responsible for spreading WNV to humans in Ontario. Both species are among the most common mosquitoes found in urban areas in the Greater Toronto Area. Forecasting a WNV outbreak is challenging, as mosquito population dynamics are influenced by complex biological and environmental factors. Management strategies undertaken by provincial and regional health agencies focus on prevention through raising awareness and reducing populations of mosquito vector species. West Nile Virus continues to be a public health concern in Ontario, with 25 cases reported in the province in 2021, resulting in seven hospitalizations and one death (Public Health Ontario, 2023).

In 2022, 2,019 mosquito larvae were collected from 47 monitoring sites. Among the seven species of mosquito collected, the most widespread was *Culex territans* (a non-vector species), which was collected from 25 of the 47 sites and was mainly found in wetlands where it represented 34% of the total mosquito assemblage. In 2022 the WNV vector *Cx. pipiens* was dominant in both wetlands (42%) and stormwater management ponds (SWMPs; 84% of larvae collected). Like previous years, monitoring results indicated that most wetlands posed minimal risk for harbouring WNV vector species**.** In 2022, three wetlands and one SWMP were identified as hotspots. With the assistance of our regional health partners and TRCA's larvicide contractor, larvicide treatments were applied to reduce mosquito larvae at these sites.

In 2022, TRCA continued to increase public WNV related issue awareness by responding to public inquiry, providing relevant information and making the annual report available on the TRCA website. We shared tips on personal protection against mosquito bites with staff and displayed posters in TRCA offices and Conservation Areas. In addition, complaints or inquiries regarding standing water or mosquito activities were addressed according to TRCA's Standing Water Complaint Procedure. Collaboration with our partners is a crucial component of effective management of WNV on TRCA properties. The City of Toronto, Peel Region, and York Region have assisted TRCA in applying larvicide treatments on selected TRCA properties in past years.

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INTRODUCTION

West Nile virus (WNV) was first discovered in the West Nile district of Uganda in 1937. Since then, WNV has spread into most parts of the world. In North America, WNV was first detected in the United States in 1999, and later appeared in Ontario in 2001. It is primarily transmitted between birds by bird-biting mosquitoes, but humans can also be infected through the bite of a mosquito that had previously fed on infected birds. Most people who become infected with WNV will be asymptomatic or experience only mild symptoms. However, rare but severe cases of WNV illness can include the development of meningitis and encephalitis, potentially resulting in death. To date, no human-to-human transmission of WNV has been documented (World Health Organization, 2017).

Most mosquito species in Ontario do not pose a serious threat of transmitting WNV. Mosquito species that can carry and transmit WNV are referred to as vector species. The primary species that spread the disease into the human populations are *Culex pipiens* and *Culex restuans* (Kilpatrick et al. 2005; Hamer et al. 2009); both are among the most common mosquitoes found in urban areas in the Greater Toronto Area. In addition, a common flood-water mosquito, *Aedes vexans*, also has a high capability of carrying and spreading WNV.

Toronto and Region Conservation Authority (TRCA) owns over 17, 000 hectares of land, including natural and constructed wetlands, woodland pools, reservoirs, and ponds. These aquatic ecosystems are considered mosquito friendly as a result of the permanent availability of standing water (Knight et al. 2003; Gingrich et al. 2006; Rey et al. 2006). TRCA's WNV Surveillance and Monitoring Program was initiated in 2003 as a measure of due diligence and at the request of our regional public health partners (Regions of Peel, York and Durham, and the City of Toronto). TRCA monitors natural aquatic habitats (collectively referred to as "wetlands" in this report) and stormwater management ponds (SWMPs) in the summer months for the presence of mosquitoes. Data collected are used to identify sites of concern or vector mosquito hotspots, which may require following up with appropriate management actions.

The objectives of the WNV Vector Mosquito Larval Monitoring and Surveillance Program are to reduce WNV risk and protect wetlands on TRCA properties through the following approaches:

- Larval Mosquito monitoring: to identify sites of potential concern through larval mosquito monitoring and take appropriate control measures if deemed necessary.
- Communication: to respond to public inquiries on WNV related issues and address standing water complaints.
- Collaboration with regional public health units: to participate in WNV advisory committees and share information and data.

LARVAL MOSQUITO MONITORING

Methods

Monitoring Site Locations

The 2022 larval mosquito monitoring program began on June 10, sampling 41 wetlands and six SWMPs across TRCA's jurisdiction including: Durham Region (8 sites), Peel Region (10 sites), City of Toronto (12 sites), and York Region (17 sites) (Figure 1). Routine monitoring stations were initially selected based on their popularity with visitors and

proximity to residential areas. These routine monitoring stations have remained mostly unchanged throughout the years.

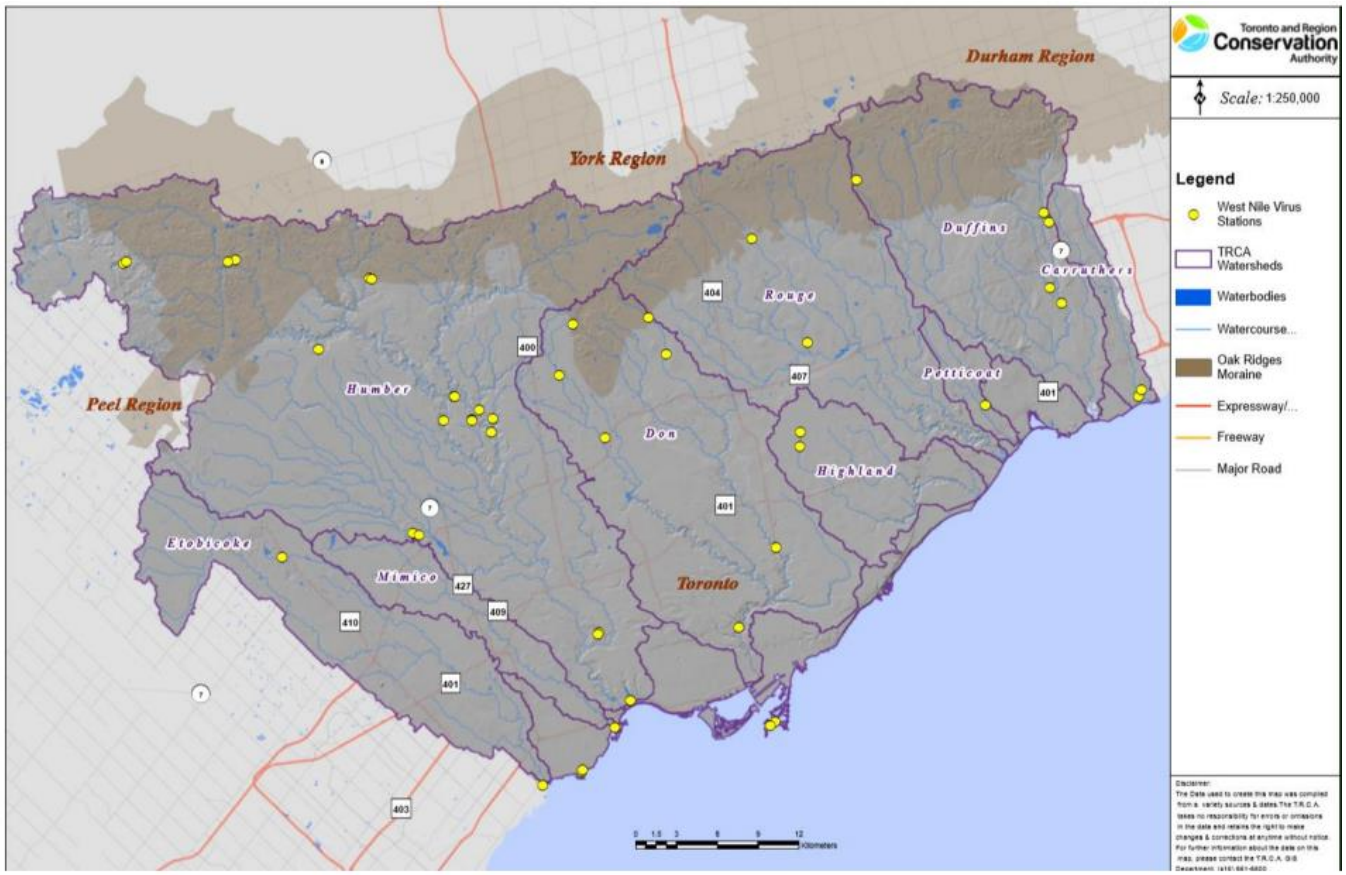

Figure 1 – West Nile Virus monitoring site locations within TRCA's jurisdiction in 2022

Sampling and Identification of Larval Mosquitoes

Each monitoring station was sampled five times in approximately two to three-week intervals from June 10 to September 6. The waterbody at each station was divided into four comparatively equal quadrants, and one sample was taken within each quadrant. Each sample consisted of collecting with a standard mosquito dipper 10 times. During sampling, the field technician used several dipping techniques to ensure that different types of mosquito habitats were sampled. Collected mosquito larvae were taken back to the lab, enumerated, and reared until they reached maturity (fourth larval instar stage). The larvae were then preserved in 70% ethyl alcohol and identified under a dissecting microscope using mosquito taxonomic keys (Wood et al., 1979; Darsie and Ward, 2005). Larvae that died before reaching maturity were not identified.

WNV Risk Assessment

WNV risk ranking was assessed for each site based on the number of vector larvae found in a sample, according to the modified Wada's method of ranking (Wada, 1956):

- Sites with no vector larvae were ranked as "***Nil***" risk;
- Sites with < 2 vector larvae per 10 dips were ranked as "***Low***" risk;

- Sites with 2 – 30 vector larvae per 10 dips were ranked as "***Moderate***" risk;
- Sites with > 31 vector larvae per 10 dips were ranked as "***High***" risk sites.

Risk ranking was applied to each species independently, instead of the cumulative number of all larvae found due to species variation in WNV transmission abilities. Sites with high risk ranking hotspots were addressed, the respective regional health unit was informed and, if warranted, the sites were treated with larvicide by a licensed contractor using an environmentally friendly larvicide, *Bacillus thuringiensis israelensis* (*Bti*). A bacterium found naturally in soils, *Bti* has been successfully used worldwide since 1982 as a biological pest control agent to combat mosquitoes and black flies (Health Canada 2011).

RESULTS

Overall Mosquito Species Diversity and Distribution

In total, 2,019 mosquito larvae representing seven species were identified from 47 routine monitoring stations in 2022. *Culex pipiens* (a vector species for WNV) was the most abundant species among all sampled stations, followed by *Cx. pipiens* (a non-vector species) and the vector species *Aedes vexans* (Figure 2). Similar to previous years, *Cx. territans* was the most widespread species, having been observed at 25 of the 47 (53%) monitoring sites. The two key WNV vectors, *Cx. pipiens* and *Cx. restuans* were found at 17 (36%) and 4 (8%) sites respectively. The vector species *Ae. vexans* was observed in high numbers at one sampling site (Albion Hills Pond 2) following rainfall.

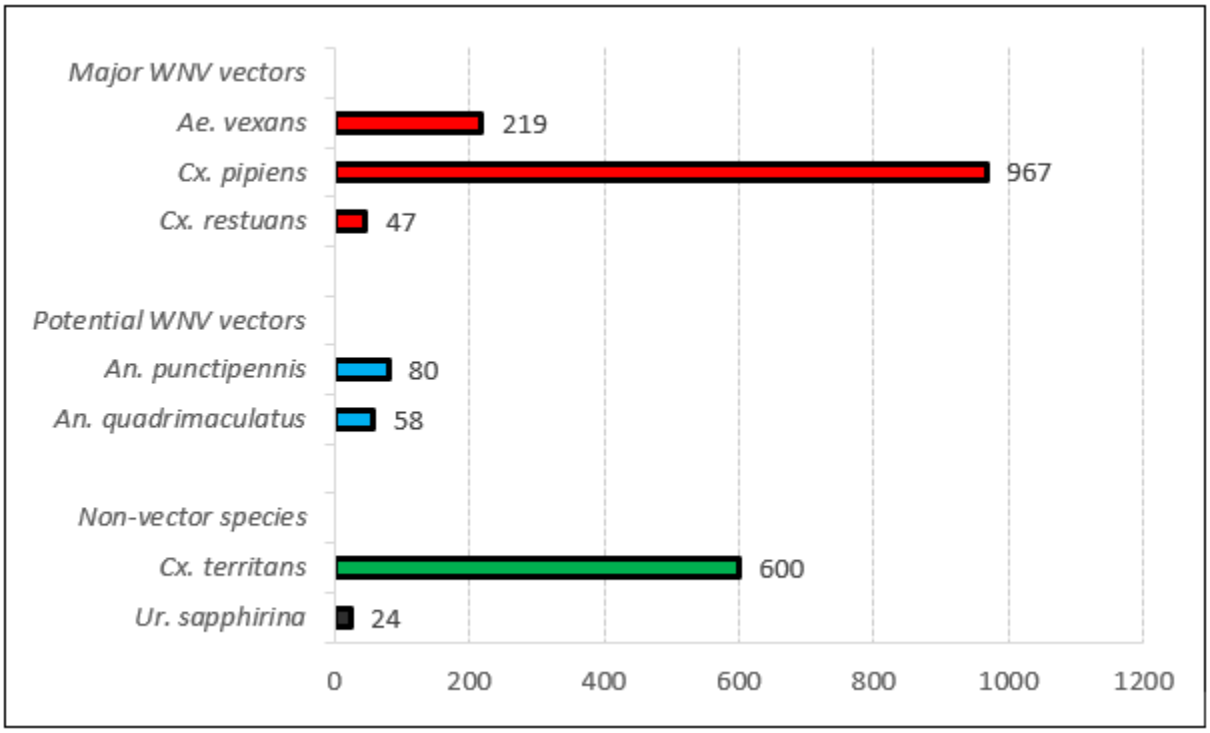

Figure 2: Mosquito species abundance in 2022

Wetlands

In total, 1.745 mosquito larvae of eight species were identified from 41 wetland monitoring sites. As in previous years, higher mosquito diversity was observed in wetlands compared to SWMPs. This finding may be attributed to the fact that more wetland sites were sampled, and wetlands generally provide more diverse habitats and shelter. *Cx. pipiens*, a vector species, was dominant in wetlands, representing 43% of all the mosquitoes collected (Figure 3). Despite the relative dominance of vector species in wetlands, most of the sites contained small numbers of larvae which would pose low to moderate risk of WNV transmission.

Similar to previous years, monitoring results showed that most wetlands posed minimal risk for harbouring WNV vector mosquitoes. Nevertheless, isolated West Nile virus vector mosquito hotspots continued to occur. The three wetland hotspots identified in 2021 were: Albion Hills Pond 2, Grenadier Pond in High Park, and Topham Pond.

Mosquitoes can only carry WNV after an adult mosquito bites an infected bird, so mosquito larvae cannot carry the virus. When a site is ranked as high-risk or a “hotspot”, it does not imply that the virus is present and poses an immediate threat to the public. The risk ranking simply indicates the presence of vector mosquito species which could potentially spread WNV to human populations after they emerge as adult mosquitoes.

Full larval mosquito monitoring risk assessment results for each monitoring station can be found in the Appendix.

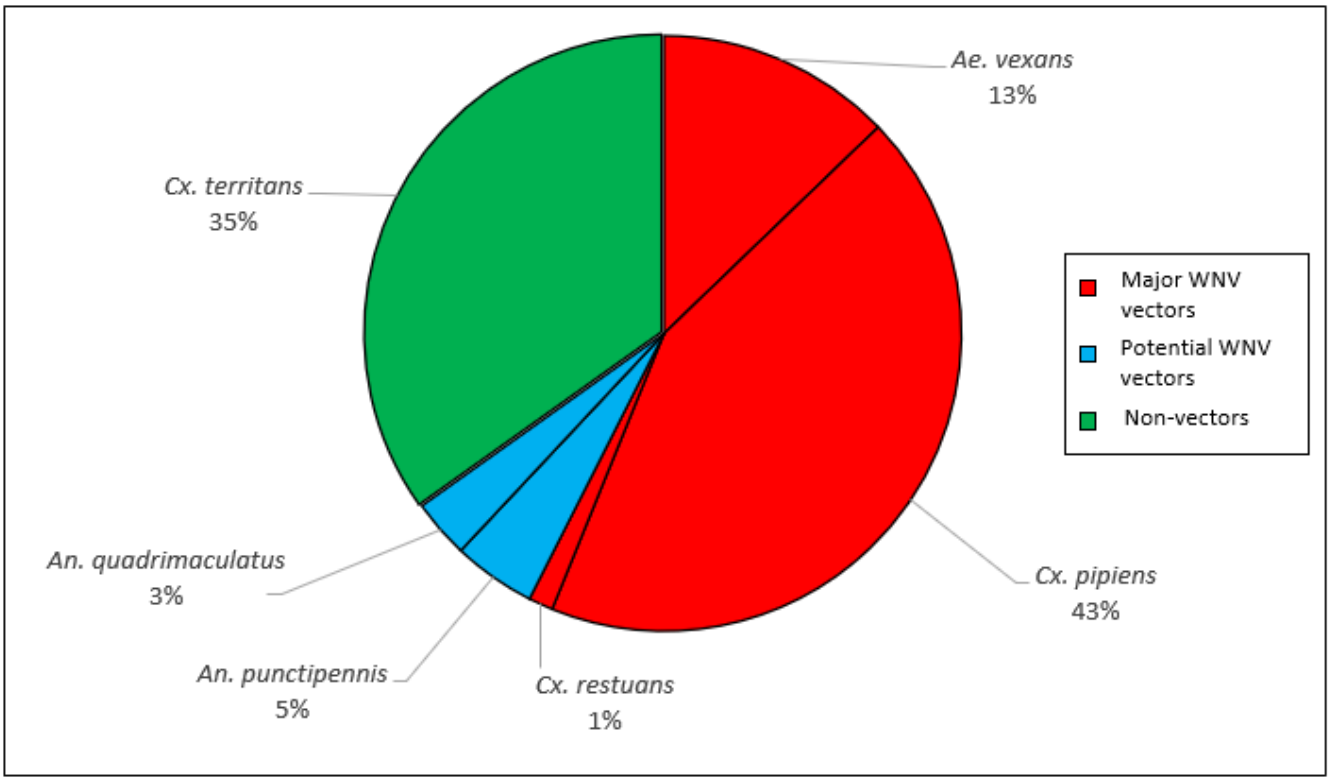

Figure 3: Mosquito species composition in wetlands in 2022, excluding species that comprised < 1% of larvae collected.

Stormwater Management Ponds (SWMPs)

From the six monitored SWMPs, 274 mosquito larvae were collected consisting of seven species (94% of which were vector species; Figure 4). Similar to previous monitoring results, *Cx. pipiens* was the dominant mosquito species (85%; Figure 4). L'Amoreaux Park North Pond was identified as a hotspot and received larvicide treatments, and most mosquitoes were eliminated after multiple applications. TRCA will continue to monitor all of these SWMPs in the future.

Full mosquito monitoring risk assessment results for each SWMP station can be found in the Appendix.

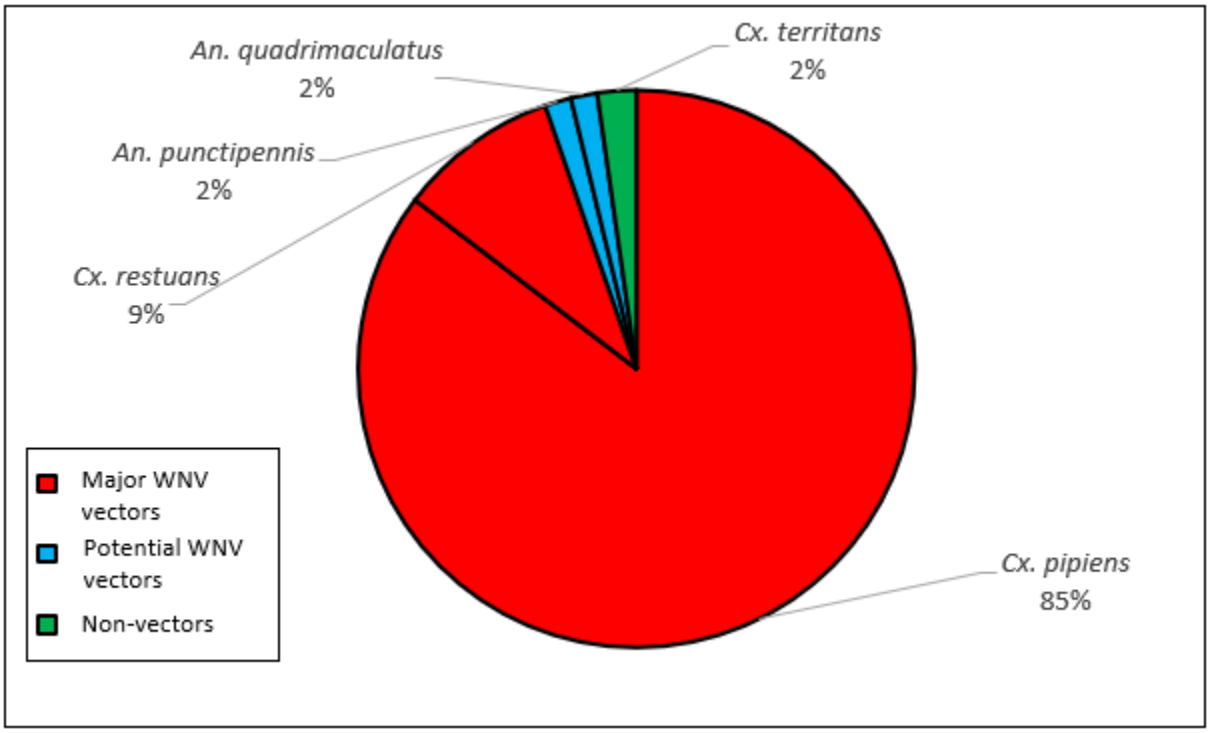

Figure 4: Mosquito species composition in SWMPs in 2022

Climate and WNV vectors in wetlands

During 20 years of monitoring, considerable variation in the proportion of WNV vectors in wetlands has been observed. In many years the dominant species in wetlands is the non-vector *Culex territans*, while in others (including the current year) it is the major WNV vector *Culex pipiens*. In the latter case, contributions by less abundant WNV vector species result in wetland mosquito populations that are comprised mostly of WNV vectors. Interannual variation in weather conditions (temperature and precipitation) are known to influence the abundance of WNV vectors including *Cx. pipiens* and *Cx. restuans* (Wang et al. 2011). To investigate the relationship between weather conditions and the proportion of WNV vectors in TRCA monitoring data, we analyzed summer temperature and precipitation against the proportion of WNV vectors in wetlands using linear regression analysis.

Weather variables were downloaded from the Environmental and Climate Change Canada historical weather database (https://climate.weather.gc.ca/index_e.html) for the Toronto City Centre station (43°37’39” N,

79°23'46" W) to represent temperature and precipitation trends for the jurisdiction. The weather variables used were monthly average and maximum temperature and total precipitation for the months from May to September from 2002 to 2022. Linear regression analysis was used to identify weather variables with significant associations with the total percentage of WNV vectors found in wetlands for each year.

The annual proportion of WNV vectors in wetlands was significantly associated ($p < 0.05$) with the monthly mean temperatures for May and July (Figure 5). *Culex pipiens* populations in temperate regions typically have two or three generational peaks over summer, with timing and magnitude of the peaks strongly influenced by temperature via effects on growth rates and mortality of the aquatic life stages (e.g., Lebl *et al*. 2013, Ciota *et al.* 2014). In southern Ontario, May and July are likely important periods of egg and larval development for the first and second generations, respectively, and are the months when temperature is likely to have the strongest effect on observed population dynamics. Along with temperature, interspecific competition is a major factor influencing mosquito populations (Ewing *et al.* 2019). The result that the proportion of WNV vectors (primarily *Cx. pipiens*) is greater than that of non-vectors (primarily *Cx. territans*) in years with higher temperatures suggests that *Cx*. *pipiens* has a competitive advantage in warmer years over *Cx. territans* in wetland habitats. This result helps to understand annual variation in the proportion of vector species in TRCA monitoring data but does not indicate increased risk of WNV transmission in warmer years because it examined the proportion of species in the community, rather than variation in the abundance of WNV vector larvae.

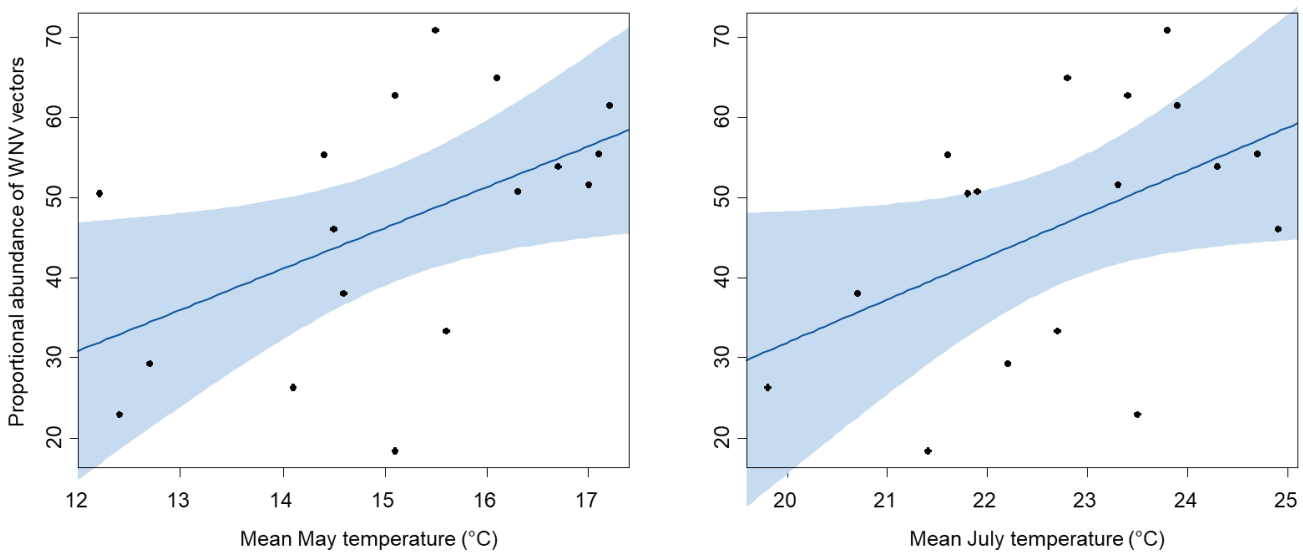

Figure 5: Influence of temperature on the proportion of WNV vectors in wetlands with regression lines ($p > 0.05$) and 95% confidence intervals (shaded areas). Only significant climatic associations (May and July mean temperatures) are shown.

COMMUNICATION

In 2022, TRCA continued to increase public WNV related issue awareness by:

- Responding to media requests and presenting related information;
- Providing information, and making the annual reports available on the TRCA website;
- Sharing tips on personal protection against mosquito bites with staff and displaying posters in TRCA offices and Conservation Areas.

In addition, complaints or inquiries regarding standing water or mosquito activities were addressed according to TRCA's Standing Water Complaint Procedure. In 2022, TRCA received one standing water complaint. After investigation, this site was not determined to be a hotspot requiring treatment.

COLLABORATION

The collaborative efforts with our regional public health partners involved providing training, notification of hot spots and participating in WNV advisory committees. Throughout our monitoring season, when a hotspot was identified, the respective public health unit was notified of our findings. Participation in regional West Nile virus advisory committees is an important part of liaising with public health partners. In addition, an Order from the Peel Region Medical Officer has been issued to TRCA annually under the Health Protection and Promotion Act, R.S.O. 1990, c. H.7 to facilitate all mosquito reduction activities within the Heart Lake Wetland Complex in Brampton.

WEST NILE VIRUS IN THE GTA AND ONTARIO

Ontario's provincial and regional health agencies continue to monitor adult mosquitoes, larval mosquitoes, and human cases as part of WNV surveillance programs. Adult mosquito monitoring is crucial for determining the immediate risk of humans contracting WNV. Larval mosquito surveillance provides information allowing regional public health units to eliminate or reduce mosquito larvae through larvicide application. Human surveillance information is used to alert the health care professionals of an outbreak and provides clues about who may be at higher risk for serious health effects from WNV. The dead bird surveillance program had been terminated since 2009 in Ontario, but the Canadian Wildlife Health Cooperative continues to test dead birds for WNV in collaboration with Ontario laboratories and the National Microbiology Laboratory in Winnipeg. Most human cases were reported in urban areas in Ontario because of the large numbers of catch basins, which are the preferred development site for the *Culex* mosquito species. Public Health Units continued to treat these catch basins on a regular basis in the summer months (4-5 treatments to be repeated at 3-week intervals).

In Ontario, the number of human WNV cases fluctuates annually (Figure 6), driven by complex environmental and biological factors. In 2021, the most recent year for which provincial data is available, the number of WNV human cases declined to 25 cases from 102 cases in 2020 (Public Health Ontario, 2022).

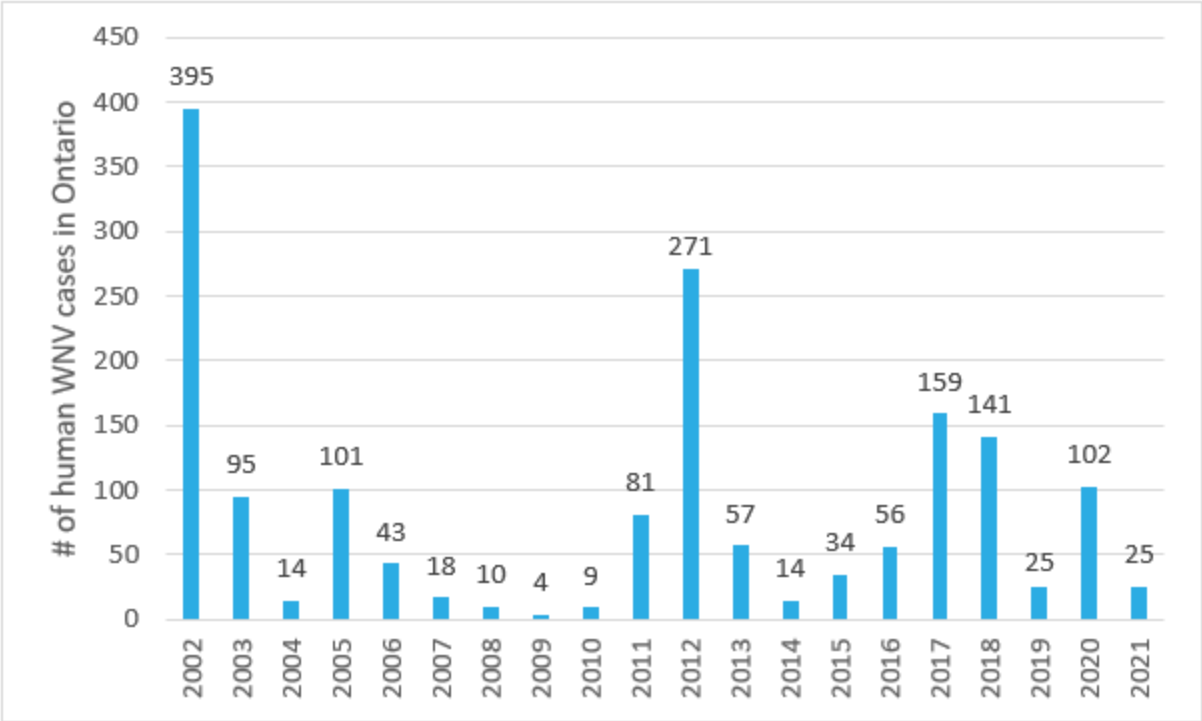

Figure 6: Human West Nile Virus cases in Ontario, 2002 – 2021

CONCLUSIONS

The results from the 2022 program supported the findings from previous TRCA studies. Generally, wetlands do not pose threats of WNV transmission. Monitoring results showed that most wetlands posed minimal risk for harbouring WNV vector mosquitoes. Nevertheless, West Nile virus vector hotspots continued to occur. In total four hotspots, including three wetlands were detected and treated with the assistance provided by TRCA's pesticide contractor, the City of Toronto Public Health, and York Region Public Health. Collaboration with Regional Public Health units is crucial in managing WNV vector hotspots in a timely manner. As vector mosquito hotspots continued to occur in our jurisdiction, TRCA staff should continue to monitor wetlands and SWMPs, to address standing water complaints from the public, and to take appropriate control measure if deem necessary.

It is difficult to predict the level of WNV activity in a given year, therefore the ability to detect hotspots, and subsequently take appropriate control measures continue to highlight the importance of regular and continuous seasonal monitoring of mosquito abundance. Larval surveillance and control is the most effective method of controlling mosquito populations. When mosquitoes are eliminated prior to becoming adults, they cannot pose a nuisance or disease problem.

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APPENDIX – MONITORING AND ASSESSMENT RESULTS 2022

Sites with no vector larvae were ranked as "Nil" risk; sites with < 2 vector larvae were ranked as "Low" risk; sites with 2 – 31 vector larvae were ranked as "Moderate" risk, and sites with > 31 vector larvae were ranked as "High" risk.

Appendix – Risk rankings for each of TRCA's WNV monitoring sites in 2021 for each of the common mosquito vector species present in the jurisdiction. Continued on following page.

Region	Site	*Aedes vexans*	*Anopheles punctipennis*	*Anopheles quadrimaculatus*	*Culex pipiens*	*Culex restuans*
Durham	Altona Forest	Nil	Low	Moderate	Nil	Nil
Durham	Carruthers Swamp Complex	Nil	Nil	Nil	Nil	Nil
Durham	Claremont Wetland-1	Nil	Moderate	Moderate	Moderate	Low
Durham	Claremont Wetland-2	Nil	Moderate	Moderate	Nil	Nil
Durham	Frenchman's Bay	Nil	Low	Nil	Nil	Nil
Durham	Greenwood Marsh	Nil	Nil	Nil	Nil	Nil
Durham	Greenwood Pond	Moderate	Nil	Nil	Nil	Nil
Durham	Shoal Point	Nil	Nil	Nil	Nil	Nil
Peel	Albion Hills Pond-1	Nil	Moderate	Nil	Nil	Nil
Peel	Albion Hills Pond-2	High	Nil	Nil	Nil	Nil
Peel	Castlemore Park	Nil	Nil	Nil	Moderate	Nil
Peel	Claireville Wetland 1	Nil	Nil	Nil	Nil	Nil
Peel	Claireville Wetland 2	Nil	Nil	Nil	Nil	Nil
Peel	Glen Haffy Trout Pond-1	Nil	Moderate	Nil	Nil	Nil
Peel	Glen Haffy Trout Pond-2	Nil	Nil	Nil	Nil	Nil
Peel	Heart Lake New	Moderate	Nil	Nil	Nil	Nil
Peel	Marie Curtis	Nil	Nil	Low	Nil	Nil
Peel	Pond-174	Nil	Low	Moderate	Nil	Nil
Toronto	Brickworks Pond 1	Nil	Low	Moderate	Low	Nil
Toronto	Col. Samuel Smith Main Pond	Nil	Low	Nil	Nil	Nil
Toronto	Col. Samuel Smith Mini Pond	Nil	Moderate	Nil	High	Moderate
Toronto	High Park Grenadier Pond	Nil	Low	Low	Moderate	Low
Toronto	L'Amoreaux North Pond	Nil	Nil	Nil	High	Moderate
Toronto	L'Amoreaux South Pond	Nil	Low	Low	Nil	Nil
Toronto	Milne Hollow	Nil	Moderate	Nil	Moderate	Nil
Toronto	Mimico Amphibian Pond	Nil	Nil	Nil	Nil	Nil

Appendix continued – Risk rankings for each of TRCA's WNV monitoring sites in 2021 for each of the common mosquito vector species present in the jurisdiction.

Toronto	Topham Pond	Low	Moderate	Low	High	Low
Toronto	TTP Goldfish Pond	Nil	Nil	Nil	Low	Nil
Toronto	TTP Triangle Pond	Nil	Nil	Nil	Nil	Nil
Toronto	Woodland Pond	Nil	Nil	Nil	High	Moderate
York	Boyd Conservation Area	Nil	Nil	Low	Moderate	Nil
York	Bruce's Mill	Nil	Nil	Nil	Nil	Nil
York	Cold Creek Pond	Nil	Moderate	Low	Nil	Nil
York	Earth Rangers Wetland	Nil	Moderate	Moderate	Low	Nil
York	Granger Wetland North	Nil	Moderate	Moderate	Nil	Nil
York	Granger Wetland South	Nil	Nil	Low	Moderate	Nil
York	Keffer Marsh	Nil	Low	Low	Nil	Nil
York	Killian Lamar	Nil	Nil	Nil	Nil	Nil
York	Pond-139	Nil	Nil	Nil	Nil	Nil
York	Pond-88.2	Nil	Low	Low	Moderate	Moderate
York	Stouffville Reservoir	Nil	Nil	Nil	Low	Nil
York	Toogood Pond	Nil	Low	Nil	Moderate	Nil

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