West Nile Virus in the Thunder Bay District, 2010

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EXECUTIVE SUMMARY

No human case of West Nile Virus (WNV) was reported from the District of Thunder Bay during 2010. Mosquitoes collected in Centres for Disease Control (CDC) adult mosquito light traps provided the information necessary to evaluate human risk from WNV.

No catch basins were inspected in the City of Thunder Bay during 2010. Negligible precipitation and high temperatures made catch basin inspections pointless because conditions were unsuitable for survival of mosquito larvae. Effort should be continued to determine the prevalence of *Culex restuans* in the catch basins during July and August, if weather permits

Two complaints about standing water as potential larval habitat were received during 2010. The first site contained 123 *Cx. restuans* larvae after 75 dips. Improved drainage was recommended; however, no action has been taken. The second site was dry when visited. An additional site that was visited during 2008 and 2009 has not been modified to prevent accumulation of water. The site remains as potential mosquito habitat and is of concern. Monitoring of these sites should occur during 2011.

The wetland habitat in a light industrial sector located near the centre of the city was examined, as recommended in 2009. No mosquito larvae were found during an extensive eight hour survey; however, minnows were recovered. This wetland is probably unsuitable habitat for mosquitoes because of predation by fish. Minnows are excellent natural control agents of mosquito larvae.

Nineteen CDC adult mosquito light traps were operated almost consistently for one night per week in the City of Thunder Bay and the Region during the eight-week period from 6 July to 25 August, for a total of 151 trap-nights. Eleven vector species (two enzootic and nine epizootic) were found in the light traps. The traps collected a grand total of 6155 specimens. A total of 4145 individuals were identified from these specimens. The identified specimens contained 1442 vectors. The vectors were pooled by species and then 24 pools of *Cx. restuans,* 4 pools of *Culex tarsalis,* 1 pool of

Ochlerotatus japonicus and 5 pools of *Aedes vexans* were tested for WNV. No mosquito pool tested positive for WNV, indicating minimal risk to the public. One *Culiseta melanura* pool was tested for Eastern Equine Encephalitis, but was found to be negative for the virus.

An estimate of the total number of each species of mosquito was calculated. C*x. restuans*, an enzootic vector, totaled 37 individuals or approximately 0.6% of the 6155 mosquitoes and *Cx. tarsalis* totaled 4 individuals (0.06%). *Culex pipiens* and *Culex salinarius* were not recovered during 2010. Epizootic vectors included *Aedes vexans* (n= 1215) (19.7%), *Anopheles walkeri* (n= 123) (2.0%) and seven other species in very low numbers. *Ochlerotatus japonicus,* which is an introduced species, a highly competent vector of WNV and considered a public health concern, was collected for the first time in the District of Thunder Bay during 2010.

Only 95.8 accumulated degree-days (AccDD) were recorded in Thunder Bay during 2010. A value of 380 AccDDs is required before a WNV outbreak occurs. The low incidence of the enzootic vector *Cx. restuans* (0.6%) and *Cx. tarsalis* (0.06%), the absence of *Cx pipiens,* and *Cx. salinarius,* as well as the low AccDD value made the amplification of WNV within the bird community to the point of “spill-over” an extremely unlikely event during the summer of 2010. The risk to humans of acquiring WNV was considered minimal. Neither larviciding nor adulticiding was considered necessary during 2010.

If the climate of Thunder Bay changes to one which is similar to the prairies (hot and dry) or to that of southern Ontario (hot and humid), there will be increased risk from WNV because of increases of *Cx. restuans, Cx. tarsalis, Cx. salinarius*, *Oc. japonicus* and perhaps the establishment of *Cx pipiens.* Any increase in these extremely competent vectors would result in increased risk of an outbreak of WNV in the District of Thunder Bay.

History of West Nile Virus in North America

West Nile virus (WNV), a mosquito-vectored disease, first appeared in North America in New York City during August 1999 and subsequently spread across North America. By 28 December 2010, Alaska was the only state in the continental United States that remained free of WNV in humans, birds, animals, or mosquitoes (Centres for Disease Control 2010a). A total of 981 cases of WNV infections occurred in humans in the United States during 2010, resulting in 45 deaths (Centres for Disease Control 2010b).

WNV was first detected in Canada during 2001 when dead birds tested positive for the virus in southern Ontario (Region of Peel 2002). The first human cases of WNV in Canada occurred during 2002 in Ontario and Quebec, with a total of 414 WNV cases and asymptomatic infections. In 2003 a total of 1495 cases occurred, followed by 26 cases during 2004, 238 cases during 2005, 151 cases during 2006, 2353 cases during 2007 which decreased to 36 cases during 2008, 8 cases during 2009 (Deacon 2010), then 5 cases during 2010 (Public Health Agency of Canada 2010b). The majority of the 2007 WNV cases were from the prairie provinces of Manitoba, Saskatchewan, and Alberta (Public Health Agency of Canada 2010a). The number of deaths attributed to WNV in Canada was 11 during 2002, 10 during 2003, 2 during 2004, 12 during 2005, 2 during 2006, 8 during 2007, 0 during 2008 and 2009 (Deacon 2010) and 0 during 2010 (Public Health Agency of Canada 2010b). WNV was active in humans only in Ontario, Saskatchewan, Alberta and British Columbia during 2010 (Public Health Agency of Canada 2010b).

Illness Caused by West Nile Virus

WNV is vectored by infected mosquitoes. Eighty percent (80%) of people infected with WNV are asymptomatic. Twenty percent (20%) of infected people develop West Nile Fever which consists of fever, tiredness, headache, muscle aches, rash and/or swollen glands. Approximately one in 150 people infected with the virus will develop a life threatening manifestation called encephalitis, *i.e.* a swelling of the brain. Symptoms of West Nile Encephalitis include fever, headache, stiff neck, disorientation, tremors, muscle weakness, paralysis and/or coma (Elliott *et al*. 2003). West Nile Encephalitis is more common, but not restricted to people over 50 years of age. The severity of the disease increases with age (Drebot & Artsob 2006). From 4% to 14% of people with West Nile Encephalitis will die as a result of their infection, whereas others may experience long-lasting, debilitating problems ranging from memory loss to muscle weakness (Elliott *et al.* 2003).

Transmission of West Nile Virus in Humans

West Nile virus is a mosquito-borne flavivirus which infects primarily birds, producing a transient high viraemia that allows transmission of the virus back to feeding mosquitoes in an amplifying cycle. The virus replicates in only some species of mosquitoes which act as the vectors of this disease. Humans can become infected as a result of bites from mosquitoes that have bitten infected birds. Other less common routes of transmission include: intrauterine, breast milk, blood transfusions, organ transplants, as well as needle stick or sharps injuries. Immuno-compromised patients and the elderly are at the greatest risk for encephalitis and death (Groner 2005).

Mosquito Vectors

Mosquitoes either overwinter with the virus or become infected with WNV when they bite infected birds. According to Reisen *et al.* (2006), replication of the virus occurs in the mosquito at a temperature above 14.3˚C; however, work by Cuevas (in Hunter & Gasparotto 2010) indicates that the threshold temperature for the development of the virus is 16.3˚C. The Ontario Ministry of Health and Long-Term Care is using a value of 18.3˚C as the threshold temperature for the calculation of viral replication. Infected enzootic vector mosquitoes bite other birds, thus transmitting the infection to the new birds (Elliott *et al*. 2003). The virus undergoes replication in the newly infected birds. These birds then become a source of infection for other mosquitoes as this enzootic phase of the disease progresses in an amplifying cycle. If amplification begins during the early spring, then by mid-summer a large number of infected birds and mosquitoes are present.

The primary mosquitoes involved in the enzootic amplification process in Ontario are *Culex pipiens* and *Culex restuans*. These mosquitoes prefer to feed on birds but may also bite humans or other mammals (Wood *et al.* 1979). *Cx pipiens* is now known to be attracted to humans at certain times during its lifecycle which means that this species also acts as an epizootic vector of WNV to humans (Russell 2008). Epizootic vectors, also called "bridge vectors", transmit WNV from birds to mammals. A third *Culex* species, *Culex tarsalis,* is the main mosquito species responsible for the transmission of WNV in western North America (Goddard *et al.* 2002). *Cx tarsalis* is now known from the Thunder Bay District (Deacon 2006), but is particularly abundant in the prairies (Wood *et al.* 1979). *Cx. tarsalis* is an unusual and highly competent vector for the genus *Culex* because it feeds freely on both birds and mammals (Wood *et al.* 1979) thus acting as both the enzootic and epizootic vector of WNV. The ability of *Cx. tarsalis* to feed on birds and mammals (humans) probably accounts for the magnitude of the WNV outbreak in the prairies during 2007.

Cx. pipiens and *Cx. restuans* prefer to lay their eggs in man-made structures that contain water such as street-side catch basins, road-side ditches, and man-made containers (tires, bottles, buckets, bird baths, roof gutters, swimming pool covers, etc.) where the eggs develop into larvae, then pupae and finally adults (Wood *et al.* 1979). *Cx. tarsalis* lays its eggs in permanent and semi-permanent ponds, irrigation and roadside ditches with emergent vegetation, as well as temporary pools or artificial containers (Wood *et al.* 1979).

"Bridge vectors" are generalist feeders, biting both birds and mammals. "Bridge vectors" are responsible for transmitting WNV from birds to humans during a "spill-over" (the epizootic phase of the disease) which occurs during the late summer. The "spill-over" occurs only when a large number of infected birds are present. *Aedes vexans* is the principal "bridge vector" in Ontario; however, this species is only moderately effective as a vector (Turell *et al.* 2001). *Ae. vexans* breeds in temporary pools, marshes, and swamps

(Wood *et al.* 1979) and is an abundant species in the District of Thunder Bay. *Ochlerotatus canadensis* is another “bridge vector” species which is sometimes abundant in the District of Thunder Bay. Larvae are found in small open ponds, temporary woodland pools, roadside ditches, cattail and sedge marshes, and muskeg pools (Wood *et al.* 1979). *Oc. canadensis* is considered a moderately effective “bridge vector” of WNV (Belton 2007).

Cx. pipiens, Cx. restuans, Cx. tarsalis, Ae. vexans, and *Oc. canadensis* are found in close proximity to human populations, which makes these mosquitoes important in the transmission of WNV. Both enzootic and epizootic vectors are required in high numbers near humans before WNV can be transmitted to humans.

Objectives of the West Nile Virus Surveillance Programme, 2010

1. A risk analysis of West Nile Virus activity in the Thunder Bay District was to be completed.

2. Adult mosquitoes in the District of Thunder Bay were to be collected using Centres for Disease Control (CDC) adult mosquito light traps.

3. Adult mosquitoes were to be identified to species and the prevalence of West Nile Virus in vector species was to be determined using Reverse Transcription-Polymerase Chain Reaction (RT-PCR).

4. The habitat used by *Culex tarsalis* in the District of Thunder Bay was to be identified, if possible.

5. Larval mosquito habitat was to be identified and inspected in the City of Thunder Bay.

6. Human cases of WNV within the District of Thunder Bay were to be noted.

7. Geographic Information Systems (GIS) mapping was to note:
   - Mosquito species distributions
   - Larval habitat locations
   - Catch basin data
   - High-risk locations

8. All municipalities within the District of Thunder Bay were to be offered a West Nile Virus information presentation outlining the TBDHU Action Plan and research findings, if desired.

9. Science-based information was to be used to determine the need for chemical control of larval and/or adult mosquitoes.

10. The 2010 report on West Nile Virus activity in the District of Thunder Bay was to be completed.

Larval Mosquito Surveillance

No catch basins were inspected in the City of Thunder Bay during 2010 because of negligible precipitation and high temperatures experienced during July and August. The catch basins were dry. Inspections of the catch basins should occur during July and August to determine the prevalence of *Cx. restuans*, if weather permits.

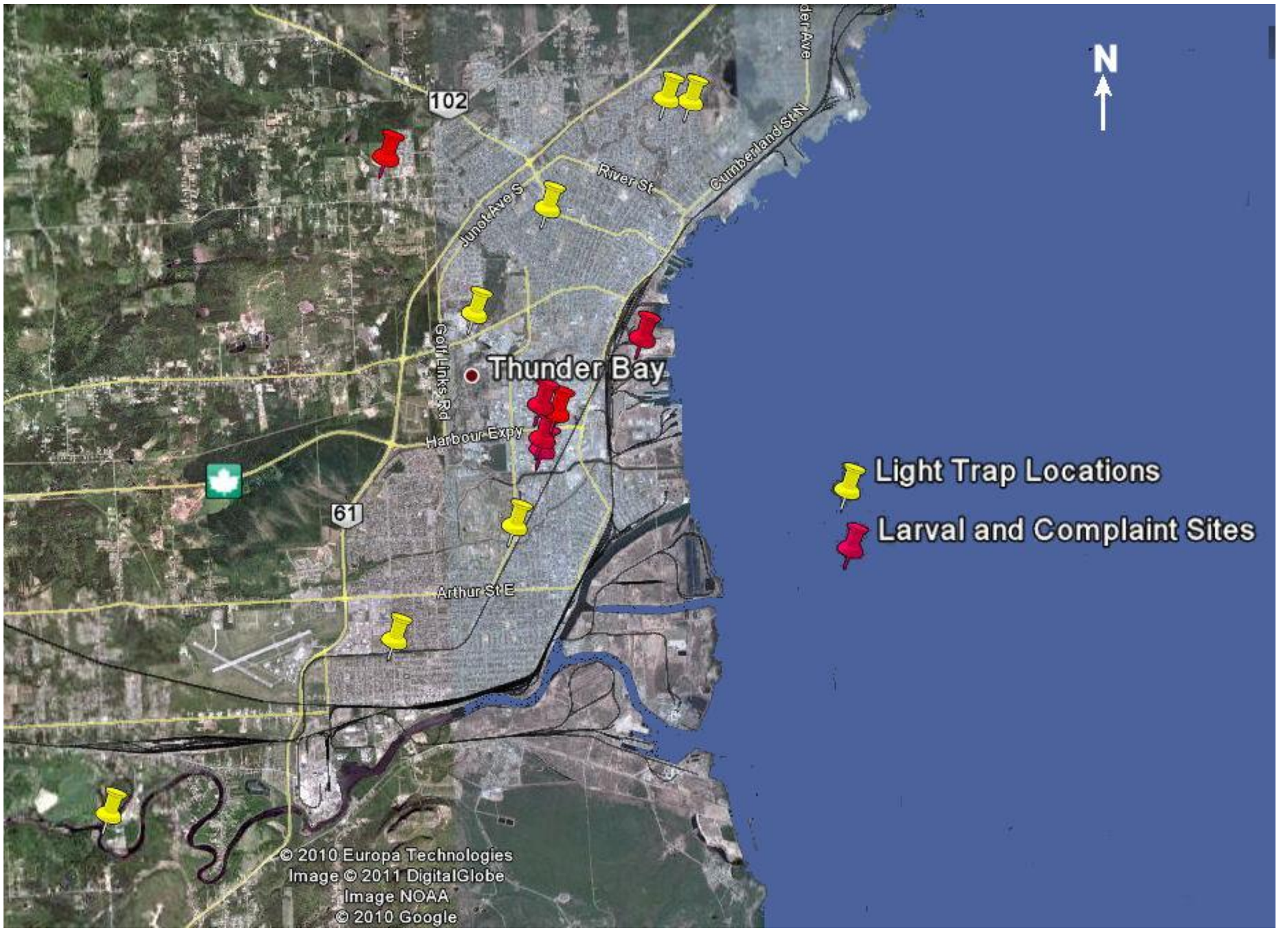
Two complaints about standing water as potential larval habitat were received during 2010 (Fig 1). The first site was visited on 22 July and sampled in two areas. The ditch along the west side of the street contained no larvae after 25 dips; however, the ditch on the east side of the street contained 123 *Cx. restuans* larvae after 75 dips. No other mosquito species were found. Improved drainage was recommended. No action has been taken. The second site was dry when visited on 21 August.

The site that was first visited during 2008 and again in 2009 has not been modified to prevent accumulation of water. The site remains as potential mosquito habitat and is of concern. Monitoring should occur during 2011.

An extensive wetland habitat (Fig. 1) in a light industrial sector located near the centre of the city was examined during September 2010 as recommended (Deacon 2010). No mosquito larvae were found during an eight hour survey; however, minnows were recovered. This site is probably unsuitable habitat for mosquitoes because of the presence of fish. Minnows are excellent natural control agents of mosquito larvae.

GIS mapping has greatly increased our ability to note areas of concern within the city, thereby facilitating precise larviciding if the need should arise. Sampling of catch basins and larval habitat is essential to provide a better understanding of the mosquito species present and their abundance in the City. Larval sampling should continue in 2011.

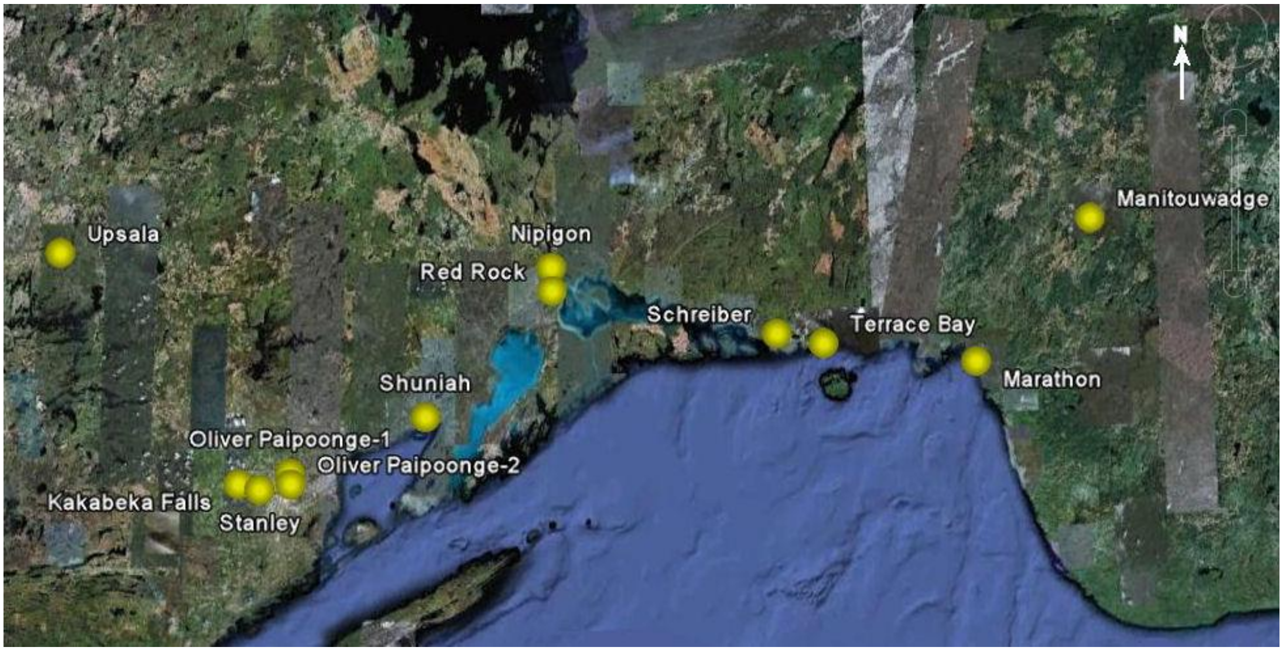
Fig. 1 Mosquito larval habitat and complaint sites, and location of CDC adult mosquito light traps in the city of Thunder Bay, 2010.



Adult Mosquito Surveillance

Nineteen CDC adult mosquito light traps were operated one night per week at fixed, secure locations: seven within the city of Thunder Bay (Fig. 1) and 12 in the surrounding "Region" (Fig. 2). The light traps were located at the same sites as 2009. Light traps were set for eight weeks from 6 July to 25 August during 2010 for a total of 151 trap-nights. One city light trap was inoperable on one occasion during the summer. Fortunately that trap collected a total of only 17 individuals during the entire summer; therefore, the results for 2010 were minimally affected.

Fig. 2 Location of CDC adult mosquito light traps in the Region of the District of Thunder Bay, 2010.



The contents of the light traps were analysed by Entomogen Inc. All the mosquitoes were identified to species unless the trap contained more than 100 individuals. These larger samples were counted and subsampled with at least 100 individuals identified randomly. The remaining mosquitoes were referred to as "extras". The light traps collected "extras" on 14 occasions during the 2010 trapping season. Entomogen Inc. also performed the viral analyses of the vector mosquitoes.

Eleven vector species (two enzootic and nine epizootic) were found in the light traps. The light traps collected a grand total of 6155 specimens. Of this grand total, 90 individuals were unidentifiable or were unidentified males (males do not blood feed; therefore, they do not transmit WNV) leaving 6065 specimens for species determination. A total of 4145 individuals were identified from these specimens, of which 1442 were vectors. These vectors were pooled by species and 34 pools were tested for WNV using Reverse Transcription-Polymerase Chain Reaction (RT-PCR). The mosquito pools included 24 *Cx restuans* four *Cx. tarsalis,* one *Ochlerotatus japonicus*, and five *Ae. vexans*. No mosquito pool tested positive for WNV. One

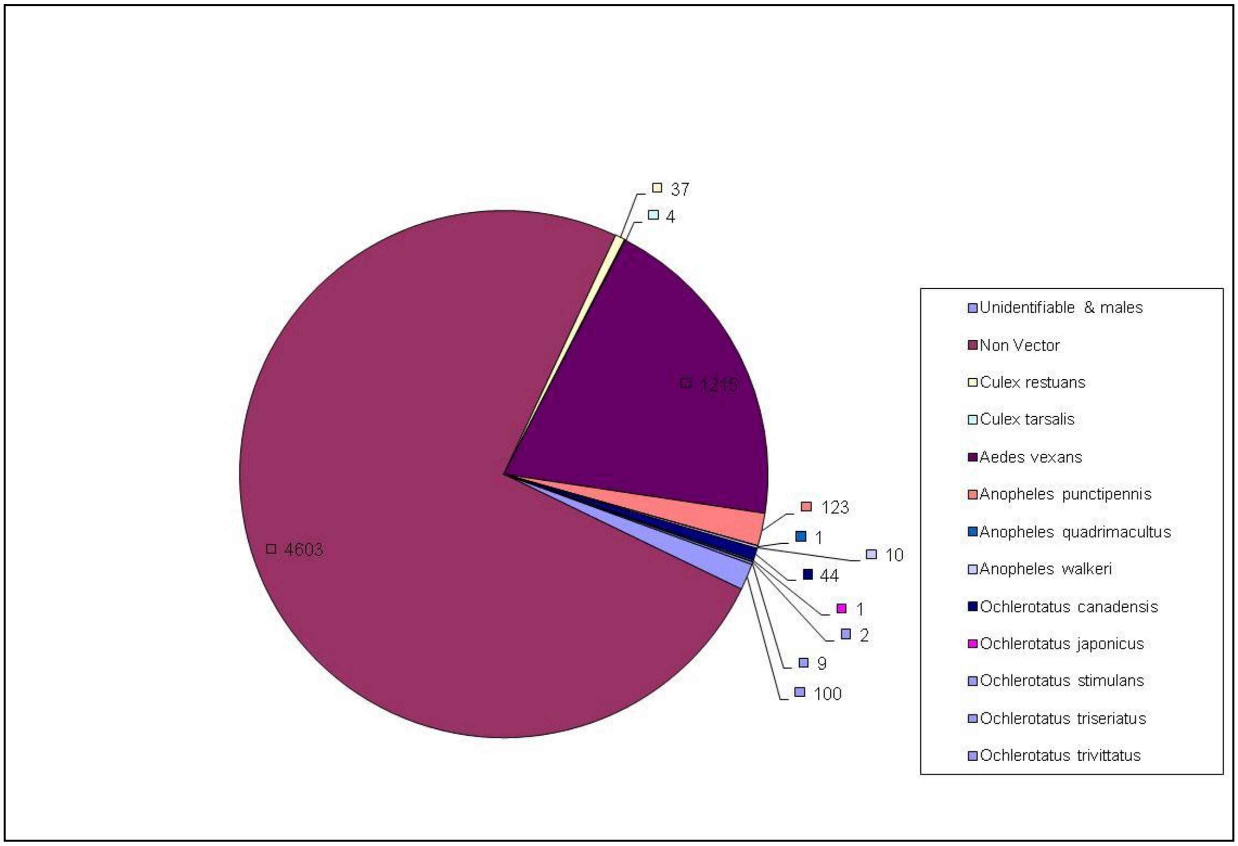
Culiseta melanura pool was tested for Eastern Equine Encephalitis, but was found to be negative for the virus.

The total number of each species of the unidentified specimens was estimated based on the ratio of the individuals identified to the individuals remaining as "extras" in the light traps per sampling event. The number of identified individuals of each species was multiplied by this factor to obtain an estimate of the approximate total number of individuals of each species collected on that night. After this conversion, vector species numbered approximately 1552 individuals, whereas non-vector species numbered 4503 individuals and unidentifiable specimens/males numbered 100 individuals. These values are a more accurate reflection of the number of each species within the mosquito community throughout the entire summer.

Cx. restuans, an enzootic vector recovered from the light traps, totaled 37 individuals (Fig. 3), about 0.6% of all the mosquitoes collected. *Cx. tarsalis*, the other enzootic vector, totaled 4 individuals (0.06%). The epizootic vectors were *Ae. vexans* (n= 1215) (19.7%), *An. punctipennis* (n= 6) (0.1%), *An. quadrimaculatus* (n= 1) (0.02%), *Anopheles walkeri* (n= 123) (2.0%), *Oc. canadensis* (n= 44) (0.7%), *Oc. japonicus* (n= 1) (0.02%), *Oc. stimulans* (n= 6) (0.1%), *Ochlerotatus triseriatus* (n= 2) (0.03%), and *Ochlerotatus trivitatus* (n= 9) (0.1) (Fig. 3).

Cx pipiens, one of the main enzootic vectors of WNV in southern Ontario, could possibly be present in the District of Thunder Bay, but still has not been positively identified after eight years of monitoring. Female *Cx pipiens* and *Cx. restuans* are considered difficult to identify to species; however, the identification of males is possible. Hundreds of *Culex* larvae have been reared to the adult stage each year of the study and all adult males have been positively identified as *Cx. restuans* only. The population of *Cx. restuans* has varied from a high of 3.0% in 2007 to a low of 0.4% in 2009. No apparent trend towards an increase or decrease in numbers is evident. The fluctuation is probably related to the extremely different weather experienced each summer since the start of mosquito surveillance in 2003.

Fig. 3 Number of individuals of vector mosquito species and non-vector mosquitoes collected in the District of Thunder Bay, 2010.



Cx. tarsalis was recovered again during 2010, although in low numbers (n= 4). *Cx. tarsalis* is of even greater concern than *Cx. restuans* as a vector of WNV. *Cx. tarsalis* is a competent vector of WNV (Goddard *et al.* 2002), readily feeding on both birds and mammals, including humans (Wood *et al.* 1979). These characteristics allow *Cx. tarsalis* to act as both an enzootic and epizootic vector. The distribution of *Cx. tarsalis* is described as present in western North America with some populations found in southeastern Ontario, and even Florida (Wood *et al.* 1979). The collection of specimens from Kakabeka Falls to Geraldton during 2005, one specimen from Red Rock during 2006, eight specimens from around the City of Thunder Bay during 2007 (Deacon 2009) and one specimen from Upsala, another from Marathon and two specimens from the Thunder Bay area during 2010 indicates that *Cx. tarsalis* is established and widespread within the Boreal forest in the District of Thunder Bay, although at very low numbers. More information is needed about the biology of *Cx.*

tarsalis to explain the occurrence of this species in the Boreal forest and to examine the effect that weather has on its abundance. Additional information will help predict the nature of the threat posed by *Cx. tarsalis* to public health.

Culex salinarius was not recovered during 2010; however, this species is of concern with regards to WNV in Thunder Bay. *Cx. salinarius* was previously reported in 2003 and again in 2005 (Deacon 2009). *Cx. salinarius* is a competent vector of WNV (Andreadis *et al.* 2004); however, the numbers of this species in the District of Thunder Bay are extremely low. Monitoring must continue to determine changes in the abundance of *Cx. salinarius* and the potential threat this species may pose to public health.

Oc. japonicus, an aggressive day-biting mosquito, was collected for the first time during 2010 at one trap site in Marathon. This species was probably introduced into New York/ New Jersey in 1998 and has since spread to southern Ontario, particularly the Windsor area (Moberly *et al.* 2005). *Oc. japonicus* is a competent vector of West Nile Virus, Saint Louis encephalitis, Japanese encephalitis and eastern equine encephalitis. *Oc. japonicus* is rapidly extending its range and should be considered a public health concern (Thielman & Hunter 2006). The occurrence of *Oc. japonicus* in Marathon may simply be a natural range expansion of this introduced species.

The Ontario Ministry of Health and Long-Term Care (OMHLTC) now uses accumulated degree-days (AccDD) (based on average daily temperatures above a threshold temperature of 18.3˚C) to evaluate the risk of a WNV outbreak (Hunter & Gasparotto 2010). The replication of WNV depends on ambient temperature. A serious WNV outbreak will only occur if mosquitoes experience at least 380 AccDD. Based on the OMHLTC threshold temperature of 18.3˚C, a total of only 95.8 AccDD were recorded in Thunder Bay during 2010 (Environment Canada 2010), which is well below the required 380 AccDD but much higher than the 12.1 AccDD that were recorded during 2009. The higher temperatures that were experienced during 2010 probably accounted for the differences seen in the species composition of the mosquito community, including the reoccurrence of *Cx. tarsalis* and possibly the appearance of *Oc. japonicus*.

The low incidence of the enzootic vectors *Cx. restuans* (0.6%) and *Cx. tarsalis* (0.06%), the absence of *Cx pipiens* and *Cx. salinarius,* as well as the low AccDD value made the amplification of WNV within the bird community to the point of "spill-over" an extremely unlikely event during the summer of 2010. The risk to humans of acquiring WNV was considered minimal. If the climate of Thunder Bay changes to one which is similar to the prairies (hot and dry) or to that of southern Ontario (hot and humid), then there will be increased risk from WNV because of increases of *Cx. restuans, Cx. tarsalis, Cx. salinarius*, and perhaps the establishment of *Cx pipiens.* Any increase in these extremely competent vectors would result in increased risk of an outbreak of WNV in the District of Thunder Bay.

Human Surveillance

No human cases of WNV were noted in the District of Thunder Bay during 2010, although two cases were reported during 2007 (Deacon 2008). Mosquitoes have tested positive for WNV in the Algoma Health District to the east of the TBDHU and one human case of WNV was reported from the Northwestern Health Unit during 2006 (Northwestern Health Unit 2006) to the west of the TBDHU. The risk of an individual acquiring WNV in the TBDHU remains low; however, continued monitoring of the adult mosquito community is necessary and the identification of larval habitat is essential if control measures are found to be necessary in the future.

West Nile Virus Control Measures

Neither larviciding nor adulticiding was required within the Thunder Bay District. WNV control measures in Thunder Bay District focused on reducing mosquito-breeding sites on private and municipal property, and on providing information to the public about the prevention of mosquito bites. During 2010, this information was disseminated to the public through pamphlets and the media. Pamphlets and/or posters were offered to health unit district offices, hospitals, children's daycare centres, seniors' centres, long-term care facilities, doctors' offices, pharmacies, golf clubs, municipal offices, community centres, resorts, sport shops, campuses, recreational camps, tree planting camps, garden centres, and parks.

Conclusions

The data collected during 2010 have again demonstrated the potential for an outbreak of WNV if environmental conditions change. *Cx. pipiens* and *Cx. salinarius* were not collected. The abundance of the vector species *Cx. restuans* increased slightly (n= 37, 0.6%) during 2010 compared to 2009 (n= 22, 0.4%); regardless, the numbers are so low that WNV posed a minimal risk to human health during 2010. The risk of an outbreak of WNV will increase only when the climate in the District of Thunder Bay changes to one more typical of southern Ontario or western Canada. Any change which increases the numbers of the extremely competent vectors *Cx. restuans, Cx. tarsalis, Cx. salinarius*, *Oc. japonicus* and perhaps allows the establishment of *Cx pipiens* would result in the increased risk of an outbreak of WNV in the District of Thunder Bay.

More information is required about catch basins, larval habitat, and the adult mosquito communities. Public outreach encouraging personal protection measures to reduce exposure to mosquitoes and the reduction of artificial breeding sites should continue. A larviciding programme to augment these proposed actions should be considered only if there is a significantly increased risk of human infection by WNV. Contingency plans for pesticide treatment should be considered to prepare for the possibility that changing weather related to global climate change creates conditions more conducive for the transmission of WNV in Thunder Bay.

Recommendations for 2011

1. Continue the adult mosquito surveillance programme within the City of Thunder Bay and in the Region using CDC light traps.

2. Continue the catch basin monitoring program, if weather permits, to identify the mosquito species that are present and the abundance of those mosquitoes within the catch basins of the City of Thunder Bay.

3. Continue the identification of larval mosquito habitat within the City of Thunder Bay.

4. Continue to monitor larval mosquito habitat that has been reported by, and is of concern to, the public.

5. Continue the use of GIS mapping to store all habitat, catch basin, and mosquito trap locations and data.

6. Investigate the biology of *Cx. tarsalis* and *Oc. japonicus,* if weather permits, to determine where these critical species occur in the Boreal forest.

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