

## **Mosquito-Transmitted Disease in Minnesota**



The primary goal of this presentation is to outline mosquito-transmitted diseases of importance to Minnesota residents.

## **Diseases Transmitted by Mosquitoes in Minnesota**

- **LaCrosse encephalitis**
- **Western equine encephalitis**
- **Eastern equine encephalitis**
- **West Nile virus disease**

While mosquito-transmitted disease is not as common here as it is in tropical climates, there are several diseases of potential concern to Minnesota residents. Low numbers of LaCrosse encephalitis cases are reported every year in southern Minnesota. In contrast, larger numbers of western equine encephalitis cases occur during infrequent outbreaks that may be spaced by 15 years or more. While eastern equine encephalitis virus has been detected in Minnesota horses, no human cases have been reported. West Nile virus arrived in Minnesota during 2002; since then 441 cases (14 fatal) were reported through 2007, and the virus appears to be established across the entire state. It is also important to remember that Minnesota residents that travel to other countries can return with tropical diseases such as malaria or dengue fever.

## **LaCrosse Encephalitis**

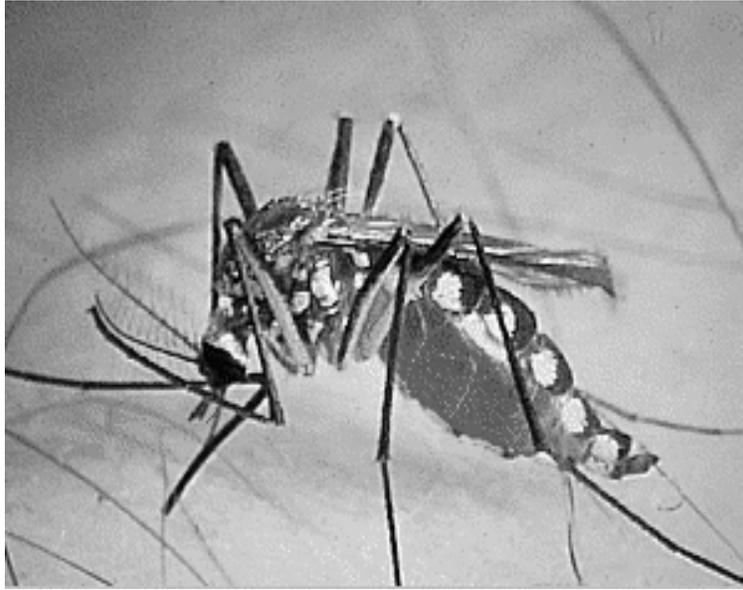
- **Family: Bunyaviridae; genus: Bunyavirus, California group**
- **Majority of cases are asymptomatic**
- **Headache, fever, nausea, vomiting, lethargy, seizures which may be frequent**
- **Disorientation, coma**
- **Median case age in MN = 6 years old**
- **1% mortality in symptomatic cases**

LaCrosse encephalitis is a disease of children. As with other arboviruses, most infections are mild (flu-like illness) or asymptomatic. The signs and symptoms listed here are seen in more severe cases. Few children die from this disease, however, approximately 15% suffer long-term mental problems.

## **LaCrosse Encephalitis**

- **Vector = *Aedes triseriatus* (Eastern tree hole mosquito)**
- **Forest-dwelling mosquito**
- **Viral amplification occurs during the summer from viremic chipmunks and squirrels**
- **Virus over-winters in mosquito eggs**

The tree hole mosquito is found in wooded areas within the southern 2/3 of Minnesota. This mosquito generally flies less than 200 yards from where it developed, so large numbers of this mosquito tend to be concentrated in small areas. Similarly, sporadic LaCrosse encephalitis cases occur in these same neighborhoods, and not as part of a regional epidemic.



This is an adult female tree hole mosquito taking a meal of human blood.

## **LaCrosse Encephalitis: Tree Hole Mosquito Breeding Sites**

- **Breeding site (stagnant water)**
  - any water collecting containers
  - old tires
  - treeholes
- **Location: shade, proximity to people**

The tree hole mosquito uses water-holding containers as breeding habitat, and the highest numbers of mosquitoes will be found in wooded areas with many breeding sites. Children are at risk for LaCrosse encephalitis when their activities bring them into these areas. Fortunately, disease prevention is as simple as removing the water-holding containers in the spring before the mosquitoes are produced.



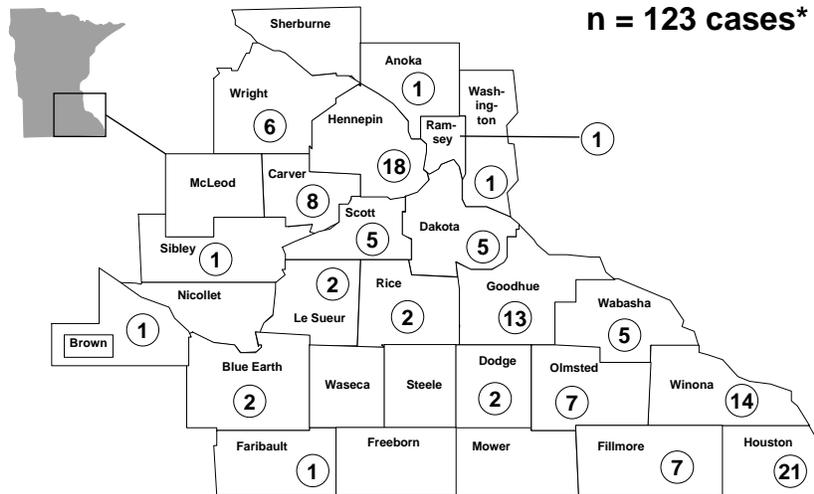
Here is the natural breeding habitat of the tree hole mosquito. Note the trees with multiple trunks. A pocket often forms in the area where the trunks meet near the ground. Rainwater and organic debris collects in these pockets and they are rapidly found and used by the mosquito. Wet tree holes are often found near the homes of LaCrosse encephalitis patients.



Man-made containers are found near almost every LaCrosse encephalitis case location. Old tires are an especially high quality breeding site for the mosquito as they can hold water, organic debris, and trap heat which speeds the development of the mosquito larvae (immature mosquitoes). Tree hole mosquito populations can reach extremely high levels in areas with many containers. This probably helps to maintain the virus, and increase the risk of transmission to people.

## Reported Cases of LaCrosse Encephalitis by County of Residence, Minnesota, 1985-2007

n = 123 cases\*

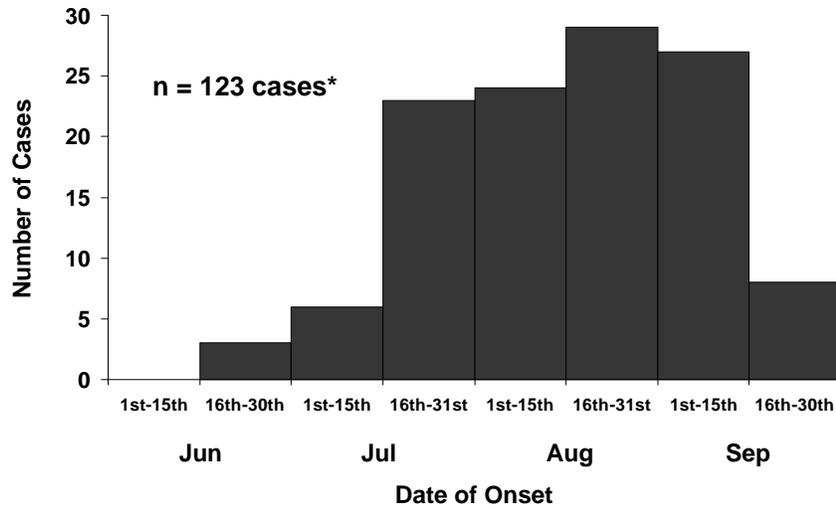


\*Cases include confirmed and probable cases



Historically, most cases of LaCrosse encephalitis were reported from southeastern Minnesota, especially from wooded areas along the Mississippi River valley. However, in recent years cases have been reported from farming regions of southcentral Minnesota. Unfortunately, while tree hole mosquitoes do best in large patches of woods, they can also survive in small wooded shelterbelts that people plant around their farms (especially if water-holding tires and other containers are present).

### Reported Cases of LaCrosse Encephalitis by Date of Illness Onset, Minnesota, 1985-2007



\* Cases include confirmed and probable cases. Three cases had unknown onset dates.

Similar to other arboviruses transmitted by mosquitoes in North America, most LaCrosse encephalitis cases occur later in the summer when infected vector populations are at their highest level.

## **Western Equine Encephalitis (WEE)**

- **Family: Togaviridae; genus: Alphavirus**
- **Majority of WEE infections are asymptomatic (1000:1 for adults; 50:1 for children)**
- **Headache, high fever, chills, vomiting**
- **Progress to lethargy, disorientation, tremors, coma**
- **Mortality, in symptomatic cases 5-10%**

Western equine encephalitis is a disease that occurs infrequently in Minnesota residents, but has the potential for a regional epidemic.

## **Epidemiology of WEE**

- **Reported in Western Canada and states west of the Mississippi River**
- **Cycle involves birds, principal enzootic vector = *Culex tarsalis***
- ***C. tarsalis* breeds in sunlit grassy marshes; feeds exclusively on birds in spring and early summer**

Western equine encephalitis virus is seen in the western United States, and circulates between birds and *Culex tarsalis* mosquitoes.

## **Epidemiology of WEE (cont.)**

- **A shift in feeding patterns to mammals occurs midsummer**
- **Few human cases reported in Minnesota; last major outbreak was in 1975 (15 cases); single cases in 1983 and 1999**
- **Humans and horses are dead-end hosts**

While the vector usually feeds on birds, under conditions where vector populations are very large or birds are scarce, they will shift over to feeding on mammals too. Cases of western equine encephalitis are often reported as part of a regional outbreak (multi-state and Canada). In 1941 there were 791 cases (90 deaths) reported cases of western equine encephalitis reported in Minnesota residents (some of these may have been due to other causes as there were fewer diagnostic tools then). However, since then human cases have only been detected in three years. Humans and horses are dead-end hosts, which means that we do not build up a high enough level of virus in our blood to infect other mosquitoes that bite us (thus we are not part of the virus transmission and maintenance cycle). There is a vaccine available to prevent this disease in horses.

## **Eastern Equine Encephalitis (EEE)**

- **Family: Togaviridae; genus: Alphavirus**
- **Majority of EEE infections are asymptomatic (40:1 for adults; 17:1 for children)**
- **Headache, high fever, chills, vomiting**
- **Progress to lethargy, disorientation, tremors, coma**
- **50-75% mortality in symptomatic cases**

Eastern equine encephalitis is another arboviral disease of humans and horses. In 2001, the virus was detected in Minnesota for the first time in recent memory with three cases in horses.

## Epidemiology of EEE

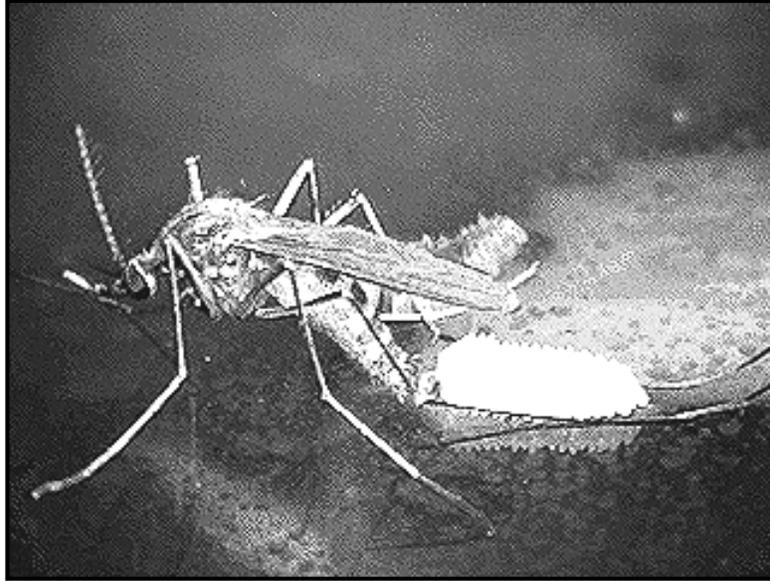
- Occurs locally along the U.S. eastern and Gulf coasts
- Principal enzootic vector = *Culiseta melanura*
- *C. melanura* breeds in freshwater swamps and feeds on birds
- Other mosquitoes transmit the virus to mammals while feeding

The primary mosquito involved with the amplification of the virus between mosquitoes and birds is *Culiseta melanura*. This bird-feeding mosquito is thought to be rare or very localized in Minnesota, but many were collected during the 2001 outbreak. In areas where this mosquito amplifies the virus in the wild bird population, other mosquito species (those that feed primarily on mammals and occasionally on birds) can then transmit the virus to horses and humans.



Here are some horses from a western Wisconsin farm where a horse died during a regional equine outbreak of this disease in 2001. Mortality is very high (70-90%) in symptomatic equine cases.

## West Nile Virus (WNV)



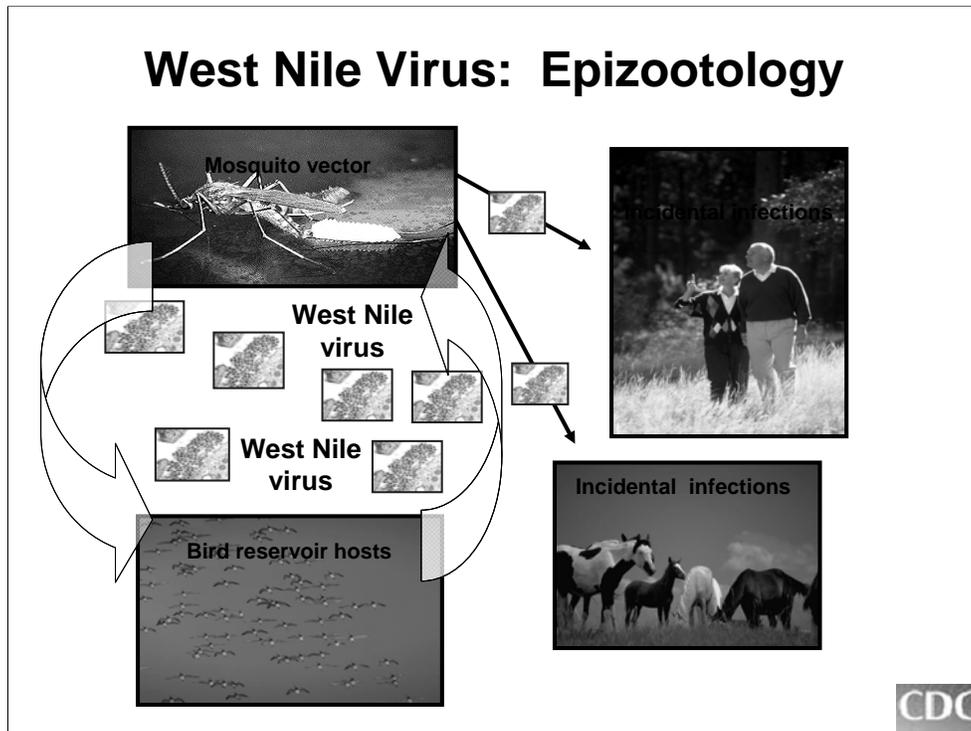
West Nile virus is the latest arbovirus to be reported in the United States, and was found for the first time in Minnesota during July, 2002. The mosquito pictured here is a *Culex* mosquito. Several species of *Culex* may be involved in amplifying this virus in wild bird populations.

## **WNV: Background**

- **First isolated in 1937 from West Nile province in Uganda from blood of a febrile woman**
  - **family: Flaviviridae**
  - **genus: Flavivirus**
  - **Japanese Encephalitis Antigenic Complex**
  - **complex includes: Alfuy, Japanese encephalitis, Kokobera, Koutango, Kunjin, Murray Valley encephalitis, St. Louis encephalitis, Stratford, Usutu, and West Nile viruses**

West Nile virus is closely related to St. Louis encephalitis, an important arboviral disease seen across much of the United States, but not Minnesota.

## West Nile Virus: Epizootology



West Nile virus circulates between mosquitoes and wild birds. Similar to eastern and western equine encephalitis, humans and horses appear to be dead-end hosts for the virus (virus levels do not high enough to infect other mosquitoes).

## **WNV Encephalitis, New York City, 1999**

- **Physician awareness of two cases of encephalitis with muscle weakness in the same community (Queens)**
- **Initially suspected to be St. Louis encephalitis**
- **Concurrent mortality of crows noticed in the same area**
- **Deaths of several exotic birds from the Bronx Zoo were noted and sent to NVSL for testing**

Prior to the 1999 West Nile fever outbreak, New York City was not known to have had problems with mosquito-transmitted disease in recent decades.



Scientists across the country have collected and tested large numbers of mosquitoes to determine which species can transmit West Nile virus in their areas. Mosquitoes are collected in carbon dioxide-baited traps, identified to species, and tested at public health laboratories for the virus. We have 50 species of mosquitoes in Minnesota, so it has been important to find the most important disease-carrying ones.

***Culex tarsalis*, the mosquito primarily responsible for transmitting WNV and WEE in Minnesota**

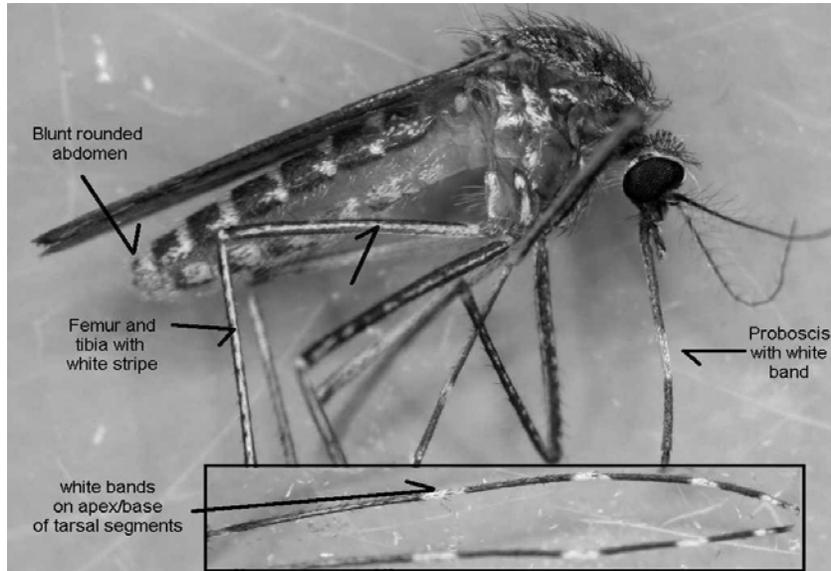


Image provided by Dale Parker

In Minnesota, *Culex tarsalis* is the mosquito that is responsible for most West Nile virus transmission to people. This mosquito is most common in the agricultural regions of western and central Minnesota. They prefer to feed on birds, but will feed on horses and people, especially in late summer when nestling birds are hard to find.



These mosquitoes reproduce in semi-permanent wetlands, especially in open grassland habitat or agricultural areas.

## **WNV: Reservoir Hosts**

- **Isolated from 308 wild bird species (1999-2005)**
- **Birds are primary amplifier hosts**
  - **reservoir**
- **Migratory bird role in distribution and reintroduction of virus into northern latitudes**
- **Role of other vertebrates not known**

We are also just beginning to understand the relative importance of various bird species in West Nile virus transmission. Many birds (especially crows and jays) are very susceptible to the virus and are rapidly killed by it. These birds may only serve as a reservoir for the virus for the brief time before they die from the infection. Other bird species such as the house sparrow do not appear to be killed by this virus as often, and may become a chronically infected reservoir of the virus. They are then able to pass the virus on to mosquitoes that bite them. House sparrows are non-migratory, however if there are other chronically infected birds that do migrate, this will likely be an important way for the virus to spread from one location to another.



The Minnesota Department of Health tested dead crows and other birds for West Nile virus from 2002-2006. Through this work we learned that West Nile virus is widely distributed across the entire state.

## **Human WNV Infection - West Nile Fever**

- **Majority of symptomatic WNV infections**
- **Sudden onset:**
  - **High fever**
  - **Headache**
  - **Fatigue**
  - **Rash**

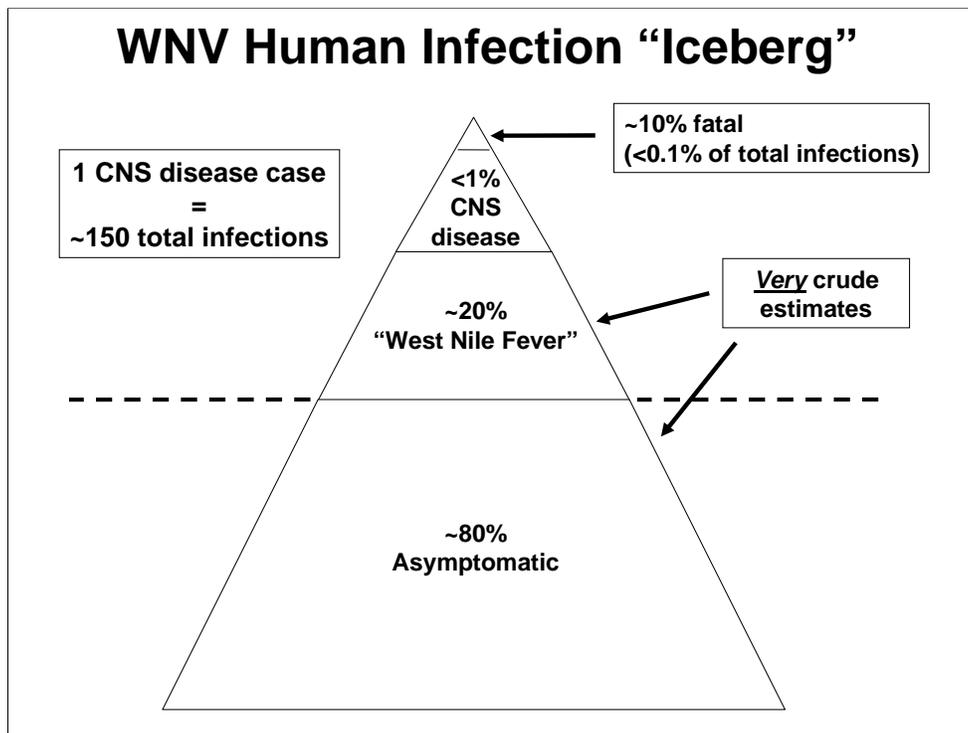


Most people who become ill from a West Nile virus infection have West Nile fever, the less severe form of this disease. However, the headaches and other symptoms can be severe enough that patients miss work and other activities for weeks.

## **Human WNV Infection – Encephalitis and Meningitis**

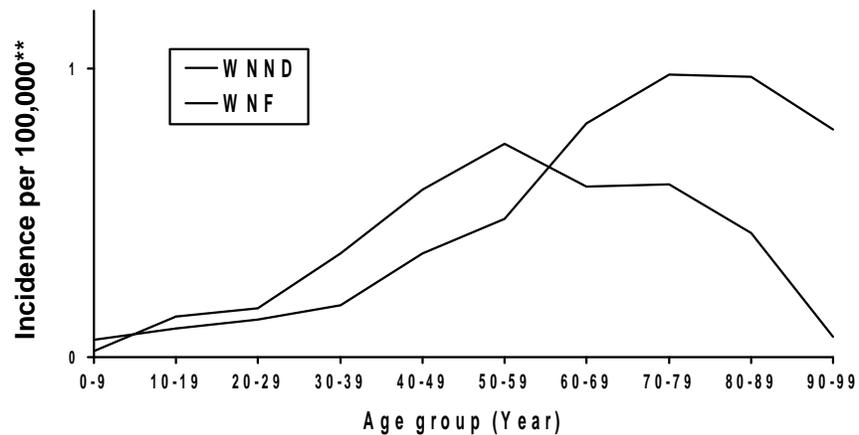
- **Less than 1% of infected people will have this severe form of WNV**
- **Stiff neck, lethargy, confusion, limb paralysis, weakness, tremors**

The most severe manifestations of West Nile virus infection are encephalitis and meningitis. West Nile encephalitis is found most commonly in the elderly, and most fatalities occur in the elderly.



Most people (about 80%) who are bitten by West Nile virus-infected mosquitoes will fight off the infection without having any symptoms at all. Almost everyone else (about 20%) develop West Nile fever. Only about one out of every 150 infections results in West Nile encephalitis or meningitis, and about 10% of these severe central nervous system cases are fatal.

## Human WNV Disease Incidence, by Age Group and Clinical Category, United States, 2004\*

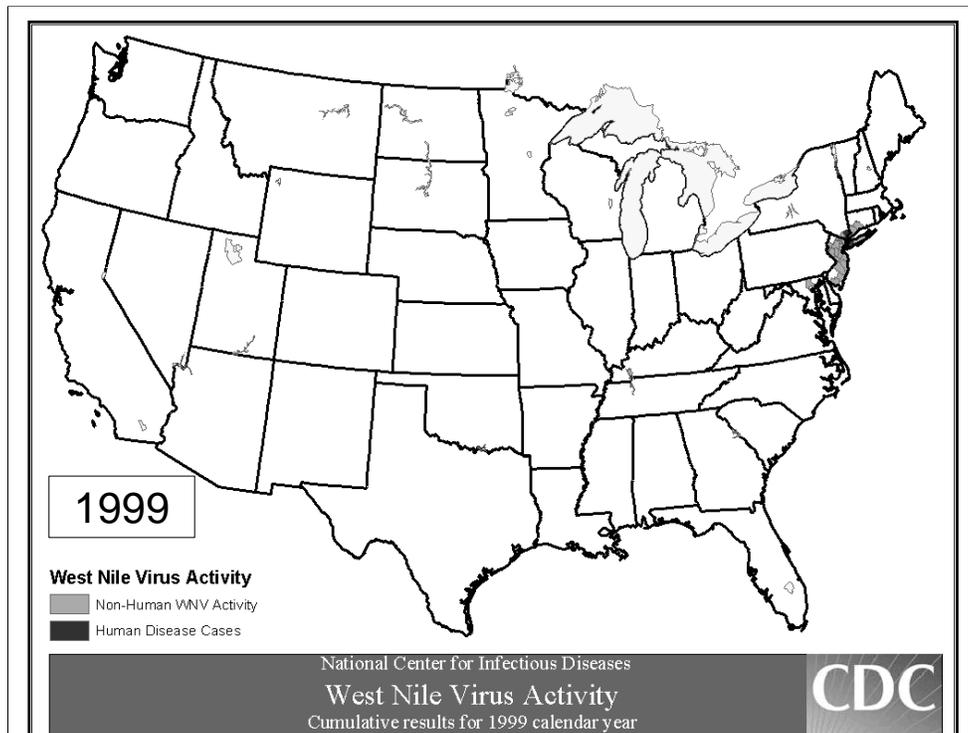


\* Reported as of 1/11/2005

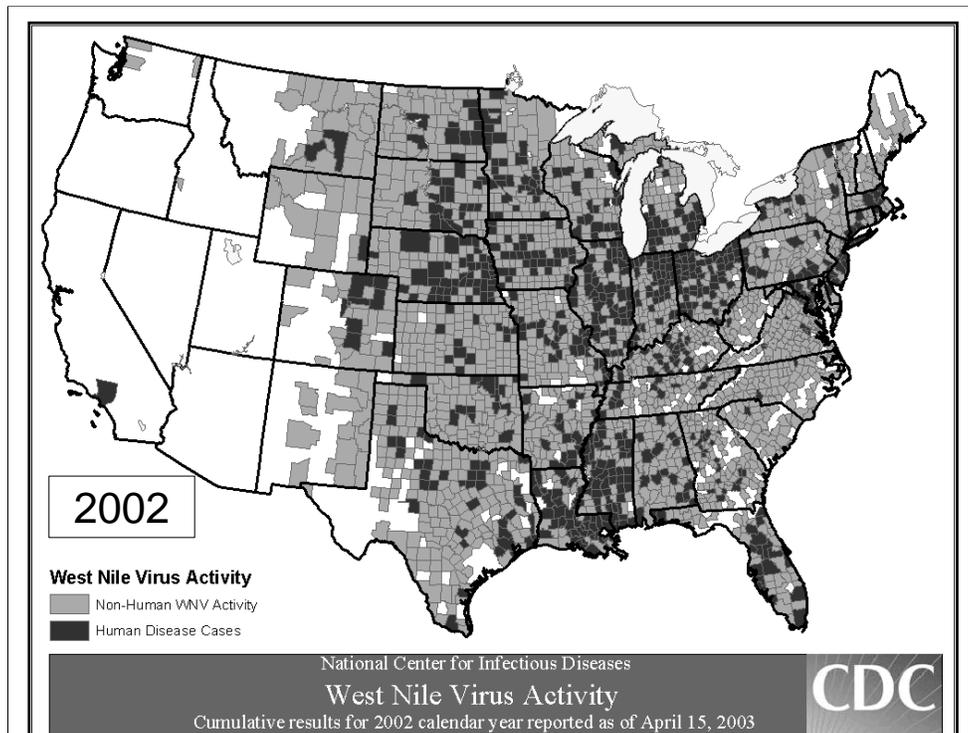
\*\* Entire US population



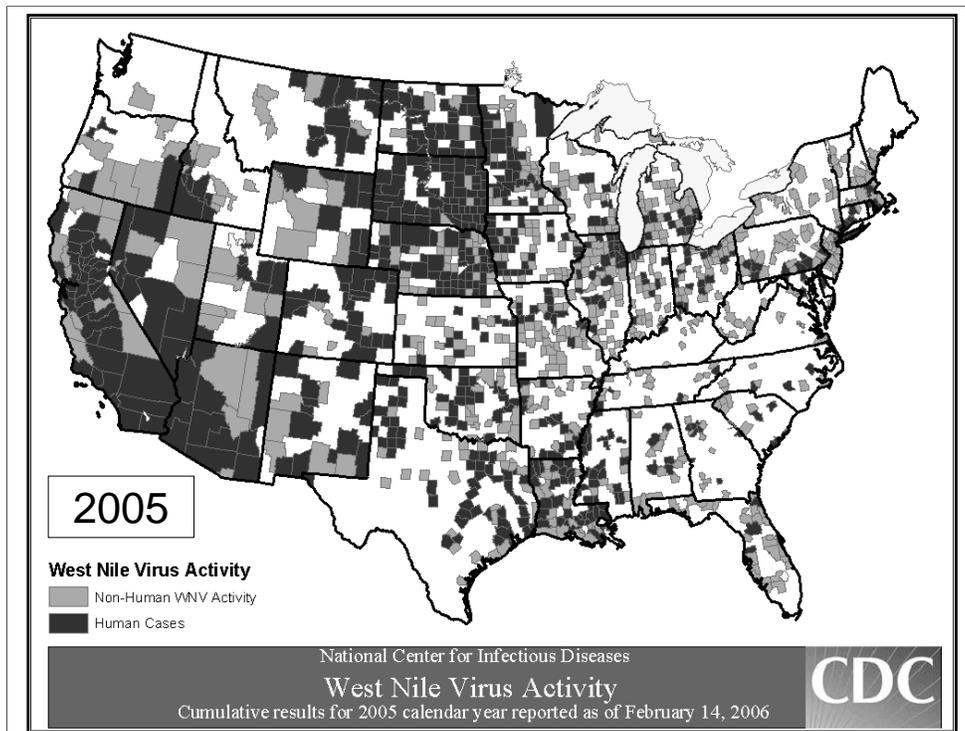
West Nile fever (WNF) occurs in people of all ages, with a peak in middle-aged people. However, West Nile encephalitis and meningitis (West Nile neuroinvasive disease- WNND) is more commonly reported in middle-aged and elderly people. While this information was from 2004, the same pattern is seen every year.



West Nile virus was first detected in North America during 1999. While West Nile virus-infected birds were detected from many eastern counties, human illness was confined to the New York City region.

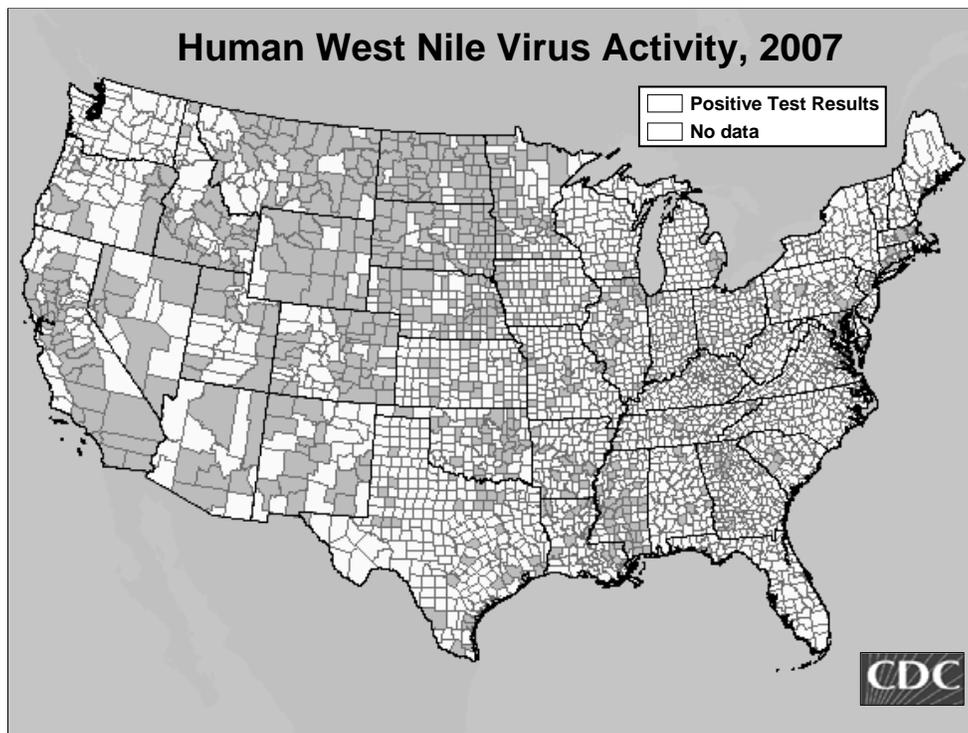


By 2002, West Nile virus had spread rapidly across the eastern two thirds of the United States. This was the first year the virus was detected in Minnesota.



In 2005, there were 2581 human cases in 42 states, and ecologic WNV activity (virus detection in birds and mosquitoes) was seen in all 48 contiguous states.

Human cases were scattered throughout the US, but most human cases were seen in CA, the southwest, and the central mountain states.



As in the past three years, most of the reported human West Nile virus cases in 2007 were residents of Great Plains states or the southwestern United States.

## **Human Cases of WNV in U.S.**

<u>Year</u>	<u>No. of Cases</u>
<b>1999</b>	<b>62 (7 fatal)</b>
<b>2000</b>	<b>21 (2 fatal)</b>
<b>2001</b>	<b>66 (9 fatal)</b>
<b>2002</b>	<b>4,156 (284 fatal)</b>
<b>2003</b>	<b>9,858 (264 fatal)</b>
<b>2004</b>	<b>2,539 (100 fatal)</b>
<b>2005</b>	<b>2,581 (83 fatal)</b>
<b>2006</b>	<b>4,269 (177 fatal)</b>
<b>2007</b>	<b>3,630 (124 fatal)</b>

The cases included in these totals met the arbovirus surveillance case definition established by the Council of State and Territorial Epidemiologists. To be called a case, the illness needed to be clinically compatible with arboviral encephalitis, with laboratory confirmation.

## Human Cases of WNV in Minnesota

<u>Year</u>	<u>No. of Cases</u>	<u>Fatalities</u>
2002	48	0
2003	148	4
2004	34	2
2005	45	3
2006	65	3
2007	101	2
	<u>441</u>	<u>14</u>

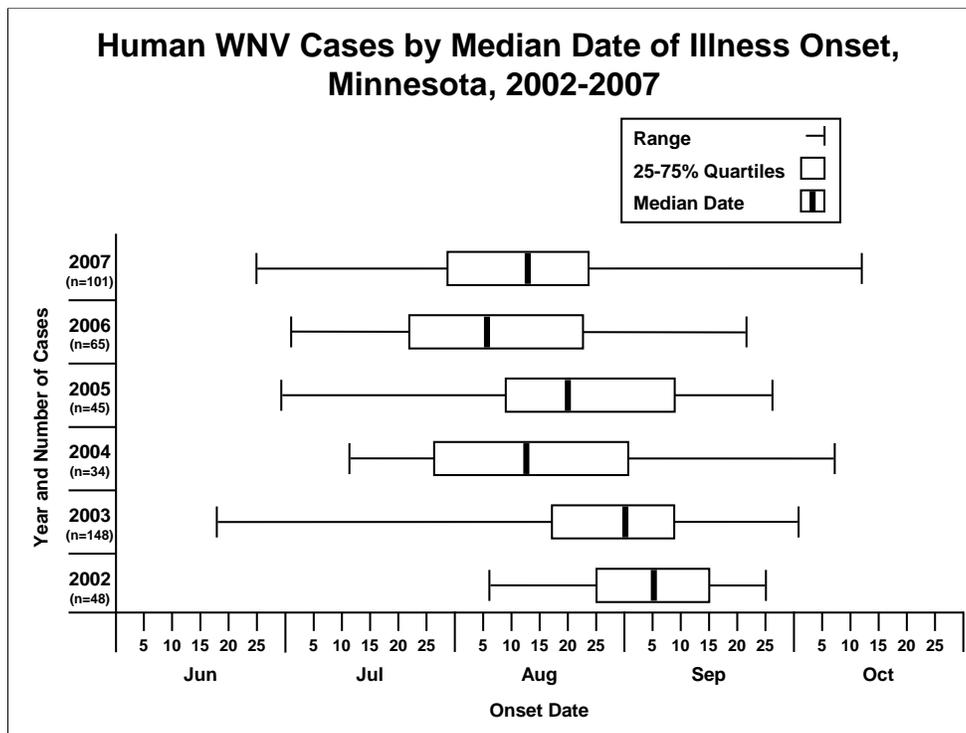
The cases included in these totals met the arbovirus surveillance case definition established by the Council of State and Territorial Epidemiologists. To be called a case, the illness needed to be clinically compatible with arboviral encephalitis, with laboratory confirmation.

## Human WNV Cases in Minnesota, 2002-2007 by Clinical Severity\*

<u>Diagnosis</u>	<u>No. of Cases (%)</u>
Fever	270 (61%)
Aseptic meningitis	89 (20%)
Encephalitis	82 (19%)

\* N = 441 cases

Almost two thirds of the West Nile virus cases reported in Minnesota have been West Nile fever cases.

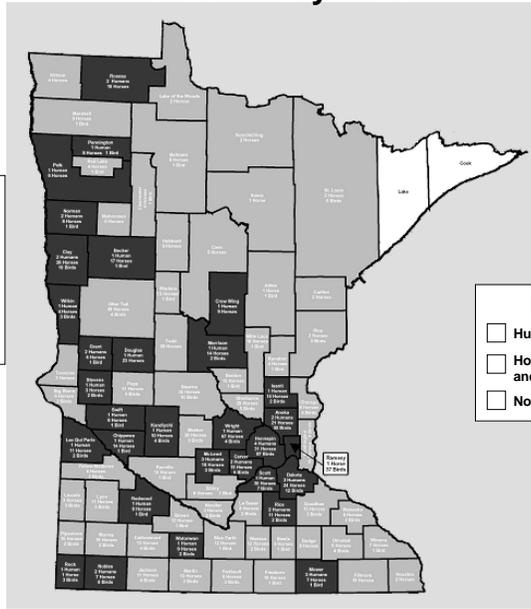


This graph plots the dates when each Minnesota West Nile virus case became ill. Half became ill before the median dates in any given year, and half after that date. Given a 3-14 day incubation period between the time of mosquito bite and the appearance of symptoms, this graph shows that most risk occurs between mid-July through mid-September, with a peak in August. Since 2003, the risk has been earlier, but the exact timing in any given year is likely dependent on the weather. Warm weather speeds the development of the mosquito and the virus.

## Minnesota West Nile Virus Monitoring Final Summary - 2002

**Confirmed Findings**

48 Humans	(31 counties)
992 Horses	(84 counties)
342 Birds	(67 counties)
- Crow	(224)
- Blue Jay	(40)
- Other/Unknown	(78)



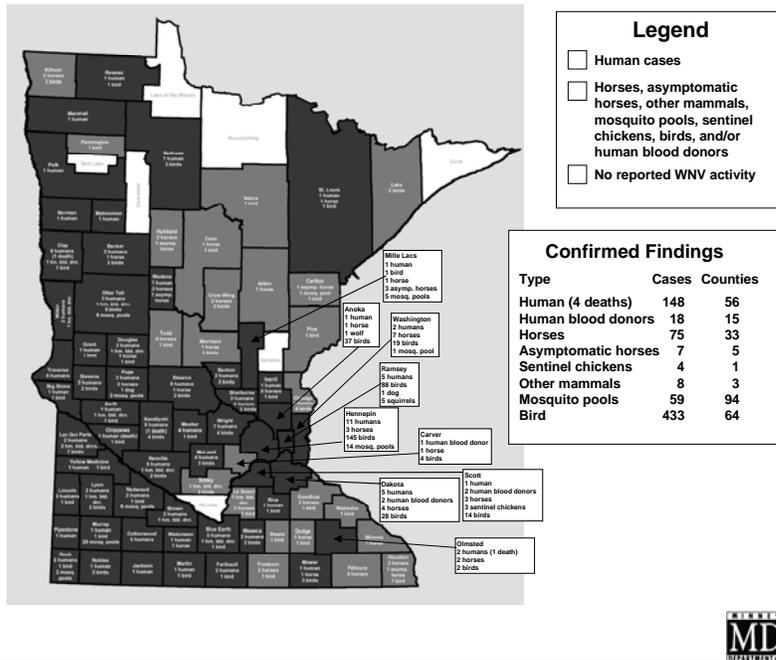
**Legend**

<input checked="" type="checkbox"/>	Human cases
<input checked="" type="checkbox"/>	Horse, mosquito pool, and/or bird cases
<input type="checkbox"/>	No WNV findings

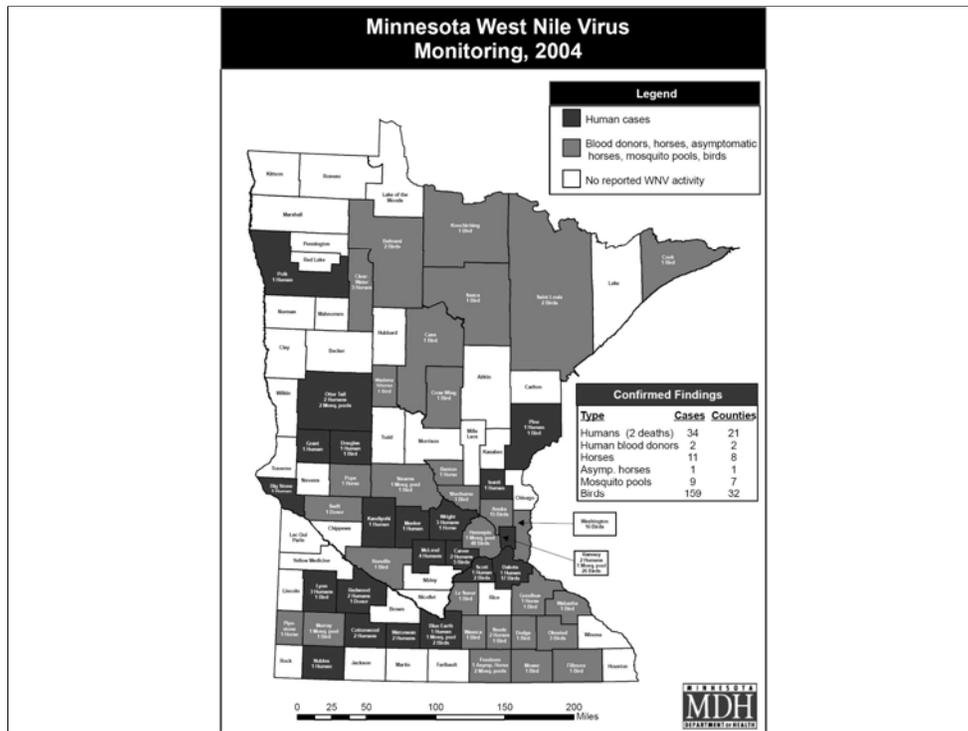


In 2002, MDH was able to detect West Nile Virus Activity in every county in Minnesota except for Lake and Cook counties. Most human and horse cases were reported in central (including the Minneapolis-St. Paul area) and western MN.

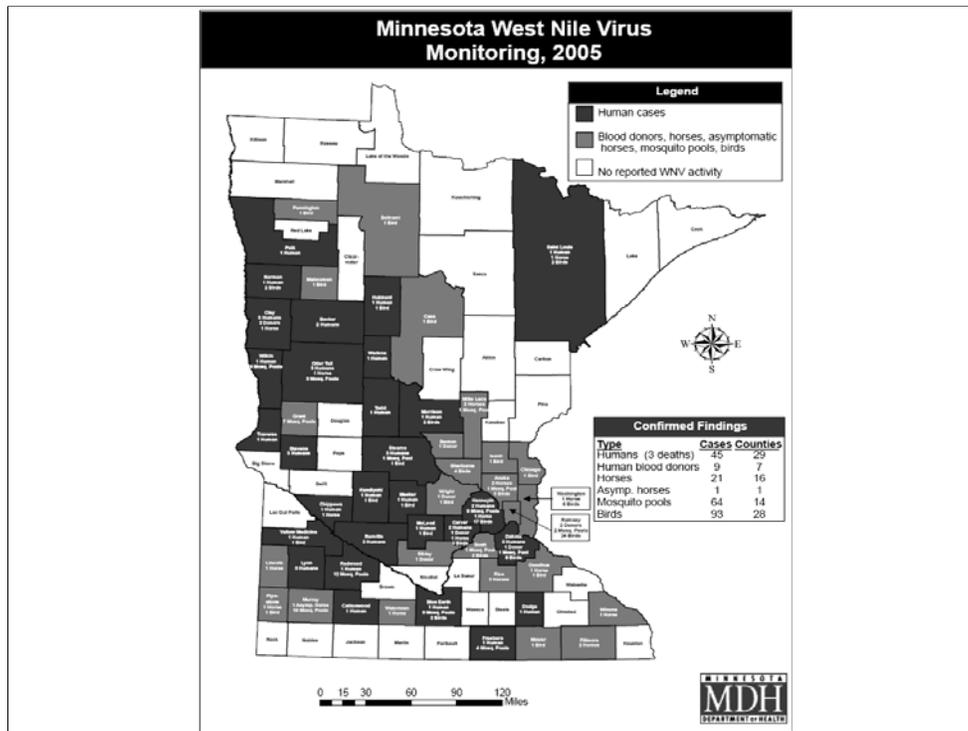
## WNV Monitoring Minnesota, 2003



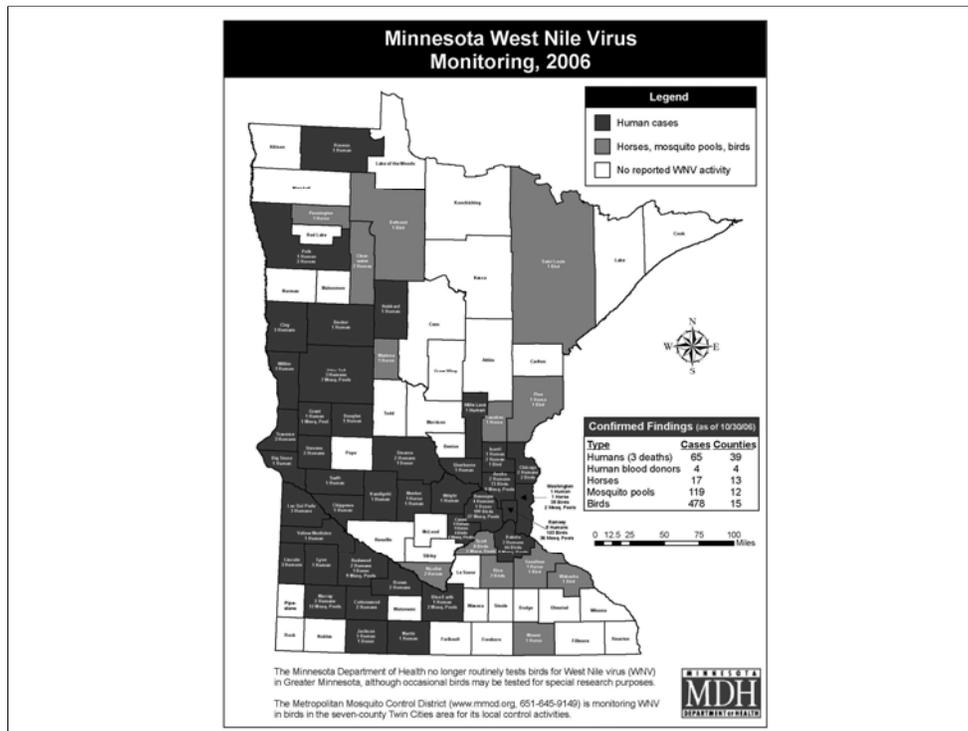
The 148 human West Nile virus cases reported in 2003 is the highest number of cases reported in Minnesota to date. Most of the disease risk was in agricultural regions of western and central Minnesota. This is the same area where *Culex tarsalis* mosquitoes are most abundant.



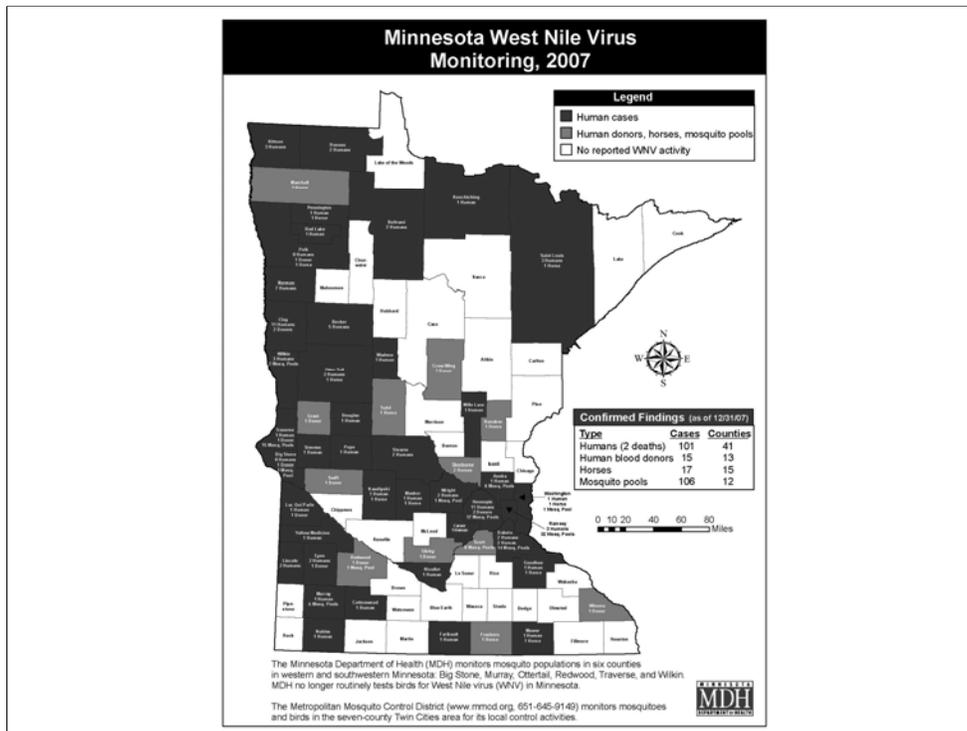
Cool weather lead to lower mosquito numbers and fewer West Nile virus cases in 2004.



As in past years, most human WNV cases occurred in agricultural areas of western and central Minnesota.



While human West Nile virus cases are reported in the Twin Cities area every year, the risk has been consistently higher in agricultural areas of western and central Minnesota.



In 2007, while most of the human West Nile virus risk was in western and central Minnesota as usual, at least two patients were likely exposed in northeastern Minnesota. Until then, all human West Nile virus cases in northeastern Minnesota had likely been exposed to virus-infected mosquitoes away from their homes while on trips or vacations. We know that the virus has spread across the state and cases are possible anywhere.

## **Human WNV Cases in Minnesota, 2002-2007**

### **Residence of locally-acquired cases\***

**Rural: 190 (52%)**

**Small town: 99 (27%)**

**City/suburb: 74 (20%)**

**\* n=363 (82%) of 441 cases that may have been exposed  
at home**

The majority of Minnesota West Nile virus cases that were likely exposed to virus-infected mosquitoes at or near home lived on rural properties or in small towns. In some eastern states, almost all West Nile virus cases occur in cities or suburbs. A different mosquito species, one that does well in cities, is responsible for transmitting the virus in those areas.

## **WNV Infection: Prevention**

- **Apply insect repellent (DEET) sparingly to skin**
- **Spray clothing with insect repellent (DEET or permethrin)**
- **Long-sleeved shirts and long pants**
- **Stay indoors from dusk until dawn**
- **Install and repair door and window screens**

People can prevent mosquito bites and West Nile virus by taking simple precautions against mosquitoes. This is most important to do for people out at dusk and dawn from mid-July through mid-September, especially in western and central Minnesota. The mosquito numbers do not have to seem “bad”; it only takes one bite to infect a person with the virus and mosquito numbers in outbreak areas are often low.

## **Prevention: N,N-diethyl-m-toluamide (DEET)**

- **Long history of use – very few confirmed cases of toxic reactions**
- **Higher % of DEET – protection not better just lasts longer**
  - **6.5% DEET = 2 hours of protection**
  - **24% DEET = 5 hours protection**
  - **protection plateaus at 50% DEET**
- **Infants and children – maximum concentration recommended by AAP is 30% (approx. 5 hours of protection)**

DEET is considered a safe and effective repellent when used according to label. However, for people who would prefer an alternative, repellents containing picaridin or lemon oil of eucalyptus will also provide protection against mosquitoes.

**For More Information,  
Please Contact:**

**Minnesota Department of Health  
Acute Disease Investigation and Control**

**651-201-5414**

**1-877-676-5414**

**[www.health.state.mn.us](http://www.health.state.mn.us)**

MDH staff are available to answer your questions on mosquito-transmitted disease. Thank you.