

Some Potential Effects of Global Warming on Vector-borne Disease Transmission in Virginia

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Climate Warming may Change or Increase Virginia's Mosquito Species Diversity

Virginia currently has 58 different resident mosquito species, including about 12 species that are known disease vectors.

However, one of the most notorious disease vector species in the world, i.e., *Aedes aegypti* (a.k.a., the yellow fever mosquito) is mostly absent from Virginia.

Aedes aegypti is historically associated with the transmission of yellow fever, as well as the dengue fever, chikungunya and Zika viruses (these viruses favor human hosts as the primary reservoir of disease for feeding mosquitoes).

Aedes aegypti feed almost exclusively on people so they are very effective in transmitting these viruses from person to person.

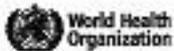
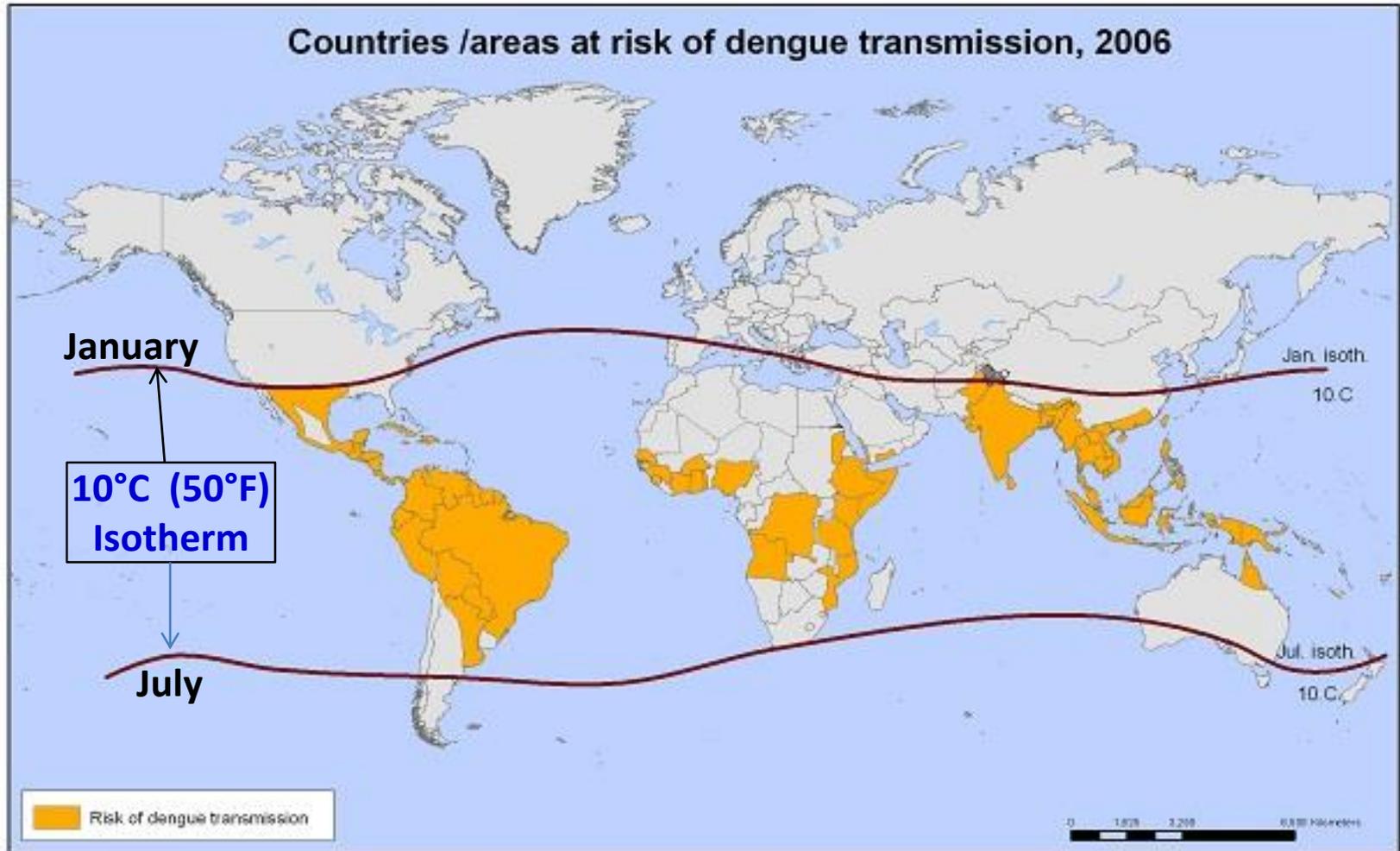
Current Geographic Limits to *Aedes aegypti*

Aedes aegypti and other related mosquito species such as *Aedes albopictus* (the **Asian tiger mosquito**) over-winter in sub tropical or temperate regions as eggs that are laid on the insides of water containers. Note: *Ae. albopictus* eggs are more resistant to freezing and their populations can survive Virginia's winters

In sub-tropical areas of the northern hemisphere in which the January average temperature (**isotherm**) is above **10°C (50°F)**, there are relatively few freezing nights and most of the *Aedes aegypti* eggs that are partially sheltered from the sky will survive the winter.

In temperate areas of the northern hemisphere where the January average temperature (**isotherm**) is below **10°C (50°F)**, very few *Aedes aegypti* eggs will be sheltered enough to survive the winter.

Current Geographic Limits to *Aedes aegypti*



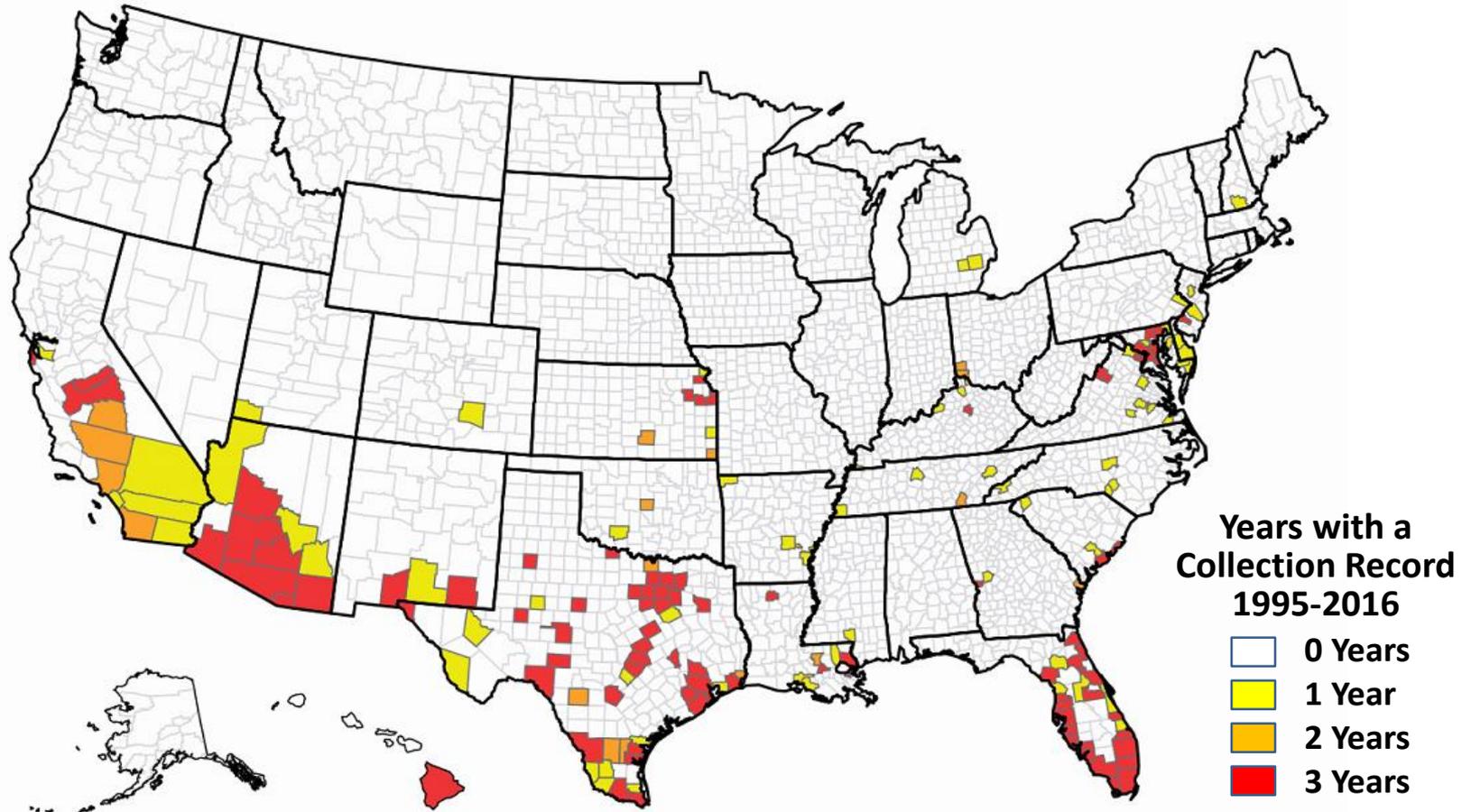
The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

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Data Source: WHO
Map Production: Public Health Mapping and GIS
Communicable Diseases (CD) World Health Organization

Isotherm = Average temperature during a given time period

Current Geographic Limits to *Aedes aegypti* in the U.S.



Map from: Hahn et al., 2016 . Reported Distribution of *Aedes (Stegomyia) aegypti* and *Aedes (Stegomyia) albopictus* in the United States, 1995-2016 (Diptera: Culicidae)

Climate Warming may Change or Increase Virginia's Mosquito Species Diversity

Currently, Virginia's January **isotherm** is approximately **3°C (37°F)**, but as the climate warms, the **10°C isotherm** may eventually move northward and reach Virginia and tropical vector mosquito species such as *Ae. aegypti* would become more common here.

A warming trend in Virginia's climate would also lengthen the duration of the *Aedes albopictus* season in Virginia and increase the chances that Virginia's **Asian tiger mosquitoes** would acquire and transmit **dengue, chikungunya** or **Zika viruses** imported by human travelers from the tropics.

Climatological Influences on Pathogen Extrinsic Incubation Periods in Mosquitoes

Mosquitoes cannot transmit most pathogens until their salivary glands are infected with the pathogen.

Contrary to popular belief, a mosquito's salivary glands do not become infected with a pathogen at the time of feeding.

When a mosquito takes in a blood-meal from an infected host, the pathogen must first multiply inside the mosquito's gut and/or develop into a new life stage within the mosquito's body before it can move to and infect the mosquito's salivary glands.

The required pathogen development or multiplication activity inside the mosquito takes time, and the time from when the mosquito consumes the pathogen to when it's salivary glands are infected is called the "extrinsic incubation period".

Climatological Influences on the Extrinsic Incubation Periods for Pathogens in Mosquitoes

The extrinsic incubation period (EIP) for a pathogen in a mosquito is controlled by the mosquito's body temperature.

At lower body temperatures - EIP is longer;

At higher body temperatures - EIP is shorter.

Insect body temperatures are largely dependent on the environmental temperature around them; mosquitoes in a hot climate will have short EIPs (shorter periods between infection and transmission).

Example: EIPs for **West Nile virus (WNV)** in *Culex pipiens* (the **northern house mosquito**):

At **30°C (86°F)** - *Cx. pipiens* develops infected salivary glands (can transmit **WNV**) within 3-days after feeding on an infected bird

At **25°C (77°F)** - *Cx. pipiens* would not be able to transmit **WNV** until at least 24-days after an infectious blood-meal.

Climatological Influences on the Extrinsic Incubation Periods for Pathogens in Mosquitoes

Shorter EIPs allow greater potential for rapid amplification of a pathogen such as **WNV, dengue** or **malaria** in mosquito populations.

The shorter EIP allows infected mosquitoes to quickly become infectious and pass their infection on to reservoir hosts which in turn infect more feeding mosquitoes that may also quickly pass their infections onto other hosts, or to people.

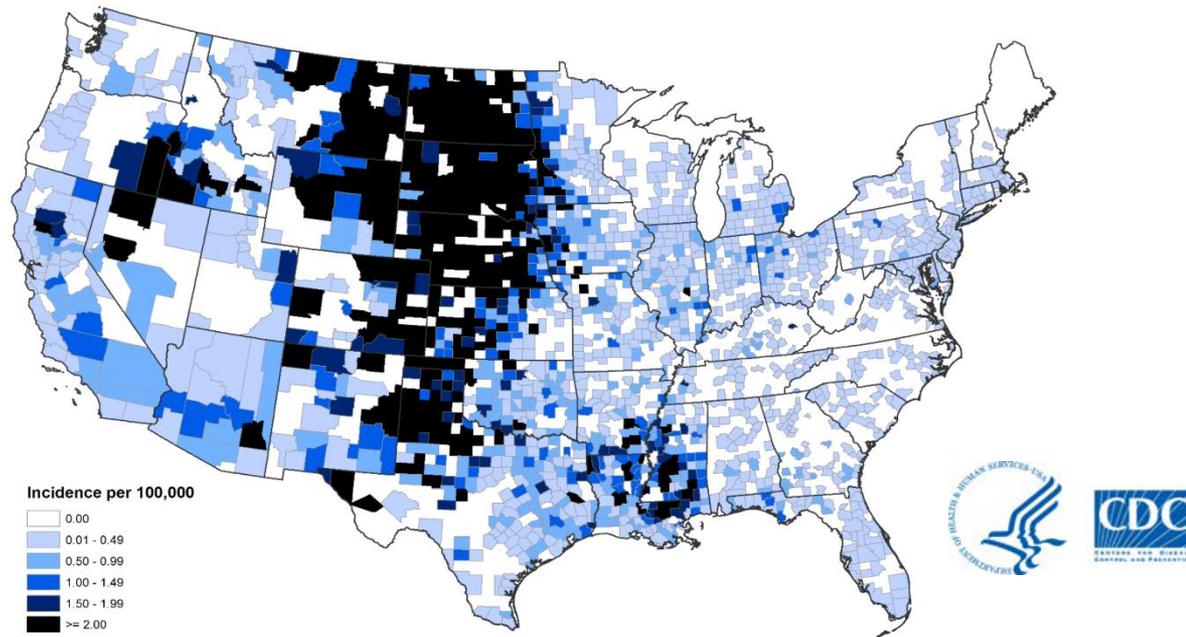
Short EIPs allow higher proportions of a mosquito population to become infected with a pathogen in a very short time-frame.

If Virginia's summers become hotter, there will be greater potential for large outbreaks of mosquito borne disease.

Other Climatological Influences on the Transmission of Pathogens by Mosquitoes

There is a considerable evidence that the transmission of WNV is favored by both hot and dry environments.

In the U.S., WNV transmission is greatest in states that are west of the Mississippi River and that are typically dryer than eastern states.



Average annual incidence of West Nile virus neuroinvasive disease reported to the CDC by county, 1999-2015

Other Climatological Influences on the Transmission of Pathogens by Mosquitoes

In the Eastern U.S., some of the worst WNV outbreaks have occurred in years and locations having summers that were both hotter and dryer than normal.

Another factor contributing to WNV transmission in the western states is the presence of an additional mosquito species called *Culex tarsalis*. This mosquito *species* is more prone to biting people than *Culex pipiens*.

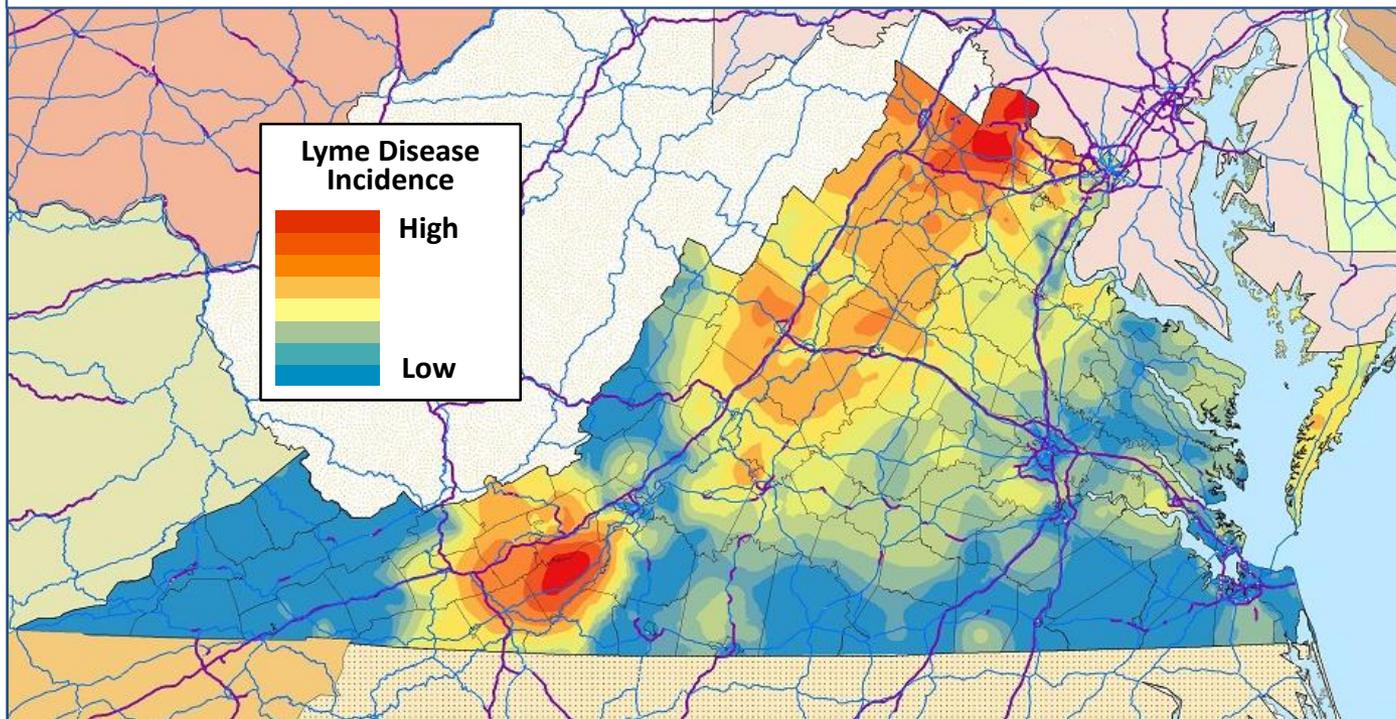
Although *Culex tarsalis* is rarely seen in Virginia there are occasional collection records here.

If climate change were to result in a dryer climate in the Eastern U.S., WNV transmission might increase in Virginia, and the dryer climate might also become more attractive/favorable to *Culex tarsalis*; conversely, a consistently wetter eastern climate might possibly result in even fewer outbreaks of **WNV**.

The Potential Effects of a Warming Climate on the Transmission of Lyme Disease

Since 2000, populations of *Ixodes scapularis*, (the blacklegged tick) and the incidence of **Lyme disease** have been greatest in the higher elevations of western Virginia (areas above 500 ft. elevation).

Geographic Lyme disease incidence in Virginia from 2008 to 2015; number of cases per census block group.



Map created using empirical Bayesian Kriging.

The Potential Effects of a Warming Climate on the Transmission of Lyme Disease

The *Ix. scapularis* tick population density in Virginia appears to be greatest in areas that are at 2,000 ft. elevation or higher, i.e., places where summer temperatures are milder.

In the lower elevations of Eastern Virginia there are *Ix. scapularis* tick populations, but these ticks are hard to collect, rarely bite people, tend to remain deep in the forest leaf litter, and feed primarily on lizards; behavior typical of “southern variant” blacklegged ticks.

A growing body of evidence suggest that *Ix. scapularis* in Virginia’s higher elevations have “northern variant” blacklegged tick behavior and that “northern variant” behavior is not favored by the hot summer temperatures seen in the lower elevations of Virginia.

Therefore, a warming climate in Virginia might ultimately limit Lyme disease transmission to the highest elevations of Virginia.

Effects of a Warming Climate on Vector-borne Disease Transmission

It is difficult to accurately predict the potential effects of climate change/global warming on vector borne diseases in Virginia because we cannot know whether this will result in a wetter or drier climate or what new diseases may appear in the future.

Current evidence suggests that climate change/global warming could lead to an increase in the incidence of certain mosquito-borne diseases.

There is also potential that climate change/global warming could reduce the incidence of some vector-borne diseases in Virginia.

Questions?