

WNV P+ T+

Disease Outbreak Forecasting Tool

West Nile Virus Case Study

**Whitepaper
For
EcoHealth Alliance**

**J.P. Dudley
Leidos**

Proposed Collaborators

Assaf Anyamba, Universities Space Research Association

LTC Jason Richardson, Department of Defense / Armed Forces Pest Management Board

Greg Ebel, Colorado State University

Andrew Huff, EcoHealth Alliance

Summary

Existing U.S military and civilian surveillance and monitoring programs cannot provide the predictive information needed to prepare for major outbreaks of WNV other potential arboviral-borne disease threats in the United States. The risks for human infections from WNV and other important vector-borne emerging / re-emerging diseases is projected to increase in conjunction with current patterns of global climate change.

At least two major human outbreaks of West Nile Virus have occurred in the past 5 years (2012; 2014), with significant impacts on public health systems in the United States in the areas in which they have occurred. Near-record number of human cases of plague and tularemia, most of which were linked to flea or fly transmission, occurred in the United during 2015.

We have identified a methodology that can be used for the predictive modeling of major outbreaks of West Nile Virus and potentially other arboviral disease outbreaks in the United States, using a combination of:

- Monthly precipitation anomaly data (NOAA HPRCC)
- Monthly temperature anomaly data (NOAA HPRCC)
- West Nile Virus human case data (CDC)

There is clear evidence that major WNV outbreaks are modulated by both precipitation and temperature regimes:

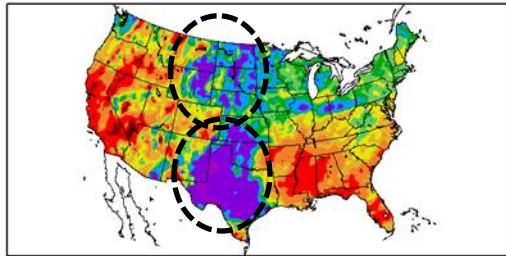
- **Precipitation:** high rainfall increases mosquito breeding rates and population densities
- **Temperature:** high summer temperatures increase virus reproduction rates within mosquitoes, and facilitate virus transmission from mother-offspring in eggs

Previous work by proposed collaborators Assaf Anyamba and Jason Richardson has shown the potential value of these type of modeling analyses for the prediction of major epidemics of Rift Valley Fever in Africa.

The proposed WNV P+T+ study would demonstrate the broader applicability of these approaches to predictive modeling of infectious disease outbreaks, and provide a potential tool for the prediction of impending major epidemics of West Nile Virus and other vector-borne diseases in the United States / North America, and other areas of the world.

2007

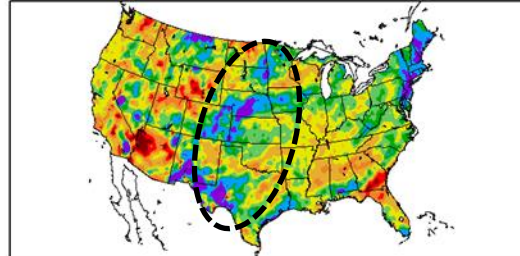
Percent of Normal Precipitation (%)
3/1/2007 – 3/31/2007



Generated 6/19/2012 at HPRCC using provisional data.

Regional Climate Centers

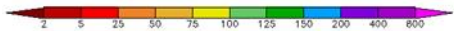
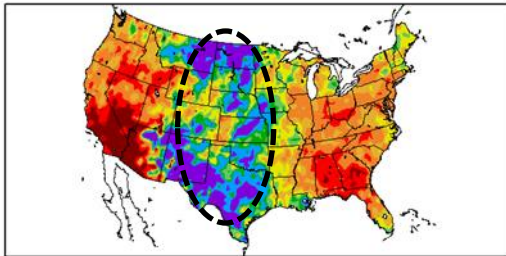
Percent of Normal Precipitation (%)
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Regional Climate Centers

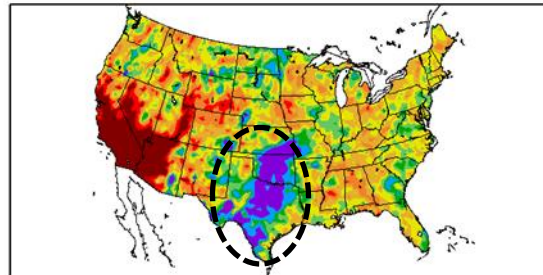
Percent of Normal Precipitation (%)
5/1/2007 – 5/31/2007



Generated 6/19/2012 at HPRCC using provisional data.

Regional Climate Centers

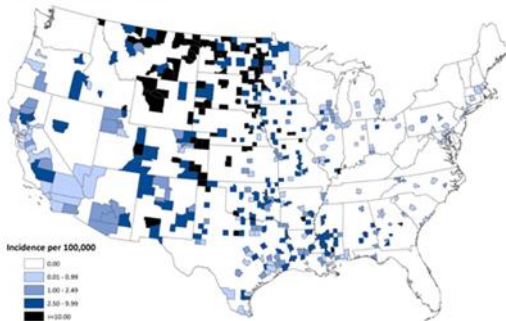
Percent of Normal Precipitation (%)
6/1/2007 – 6/30/2007



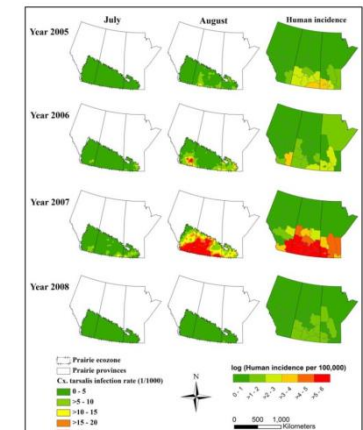
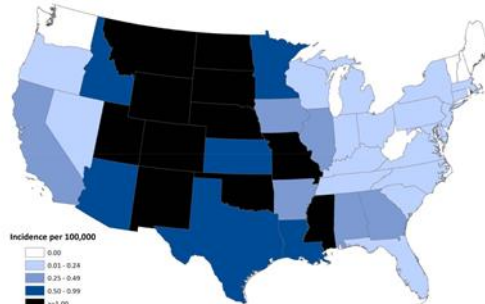
Generated 6/19/2012 at HPRCC using provisional data.

Regional Climate Centers

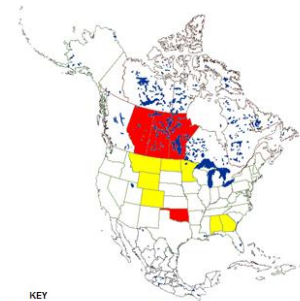
West Nile virus neuroinvasive disease incidence reported to ArboNET, by county, United States, 2007



West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2007

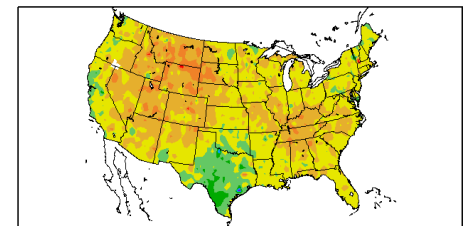


(Chen et al. 2013)



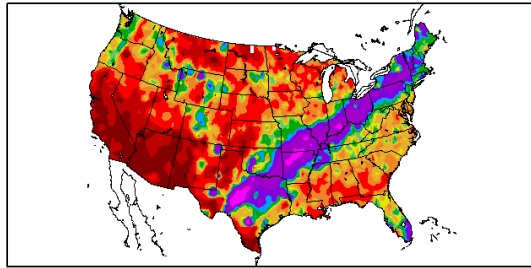
KEY
 red provinces and states reporting record numbers of human WNV cases for 2007
 yellow 2007 totals at least 100% above annual median/mean values reported for 2004-2006

Departure from Normal Temperature (F)
7/1/2007 – 9/30/2007

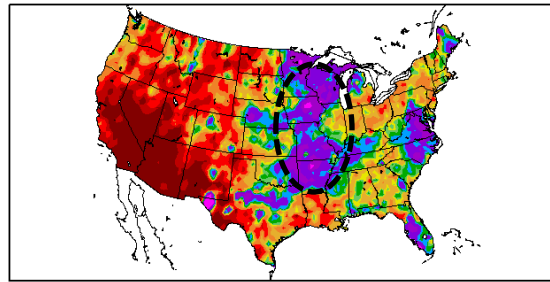


Generated 10/1/2007 at HPRCC using provisional data. NOAA Regional Climate Centers

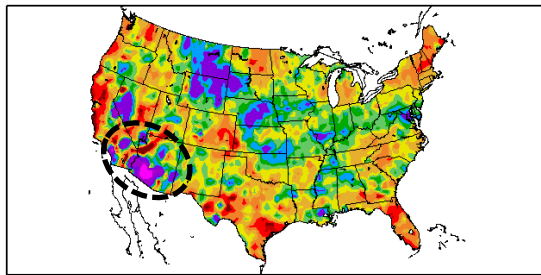
Percent of Normal Precipitation (%)
3/1/2008 – 3/31/2008



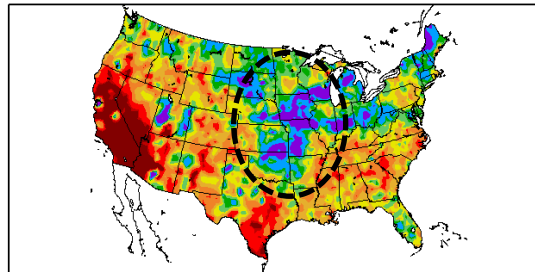
Percent of Normal Precipitation (%)
4/1/2008 – 4/30/2008



Percent of Normal Precipitation (%)
5/1/2008 – 5/31/2008



Percent of Normal Precipitation (%)
6/1/2008 – 6/30/2008

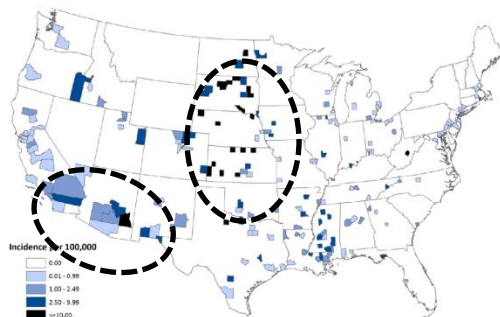


2008

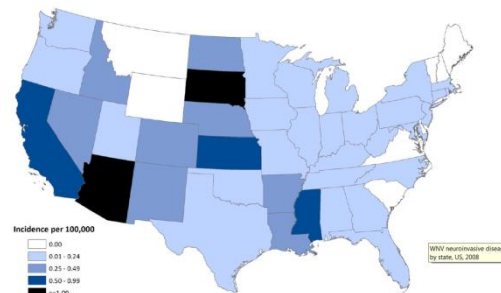
Generated 6/2/2008 at HPRCC using provisional data. NOAA Regional Climate Centers

Generated 7/2/2008 at HPRCC using provisional data. NOAA Regional Climate Centers

West Nile virus neuroinvasive disease incidence reported to ArboNET, by county, United States, 2008

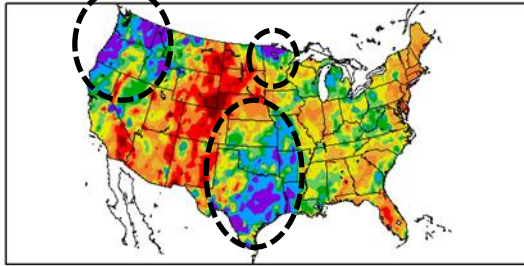


West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2008



2012

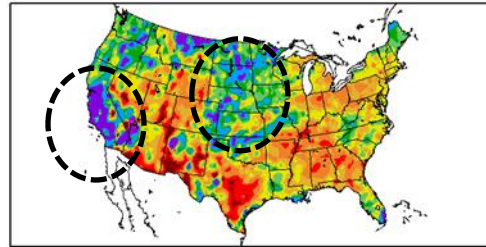
Percent of Normal Precipitation (%)
3/1/2012 – 3/31/2012



Generated 4/1/2012 at HPRCC using provisional data.

Regional Climate Centers

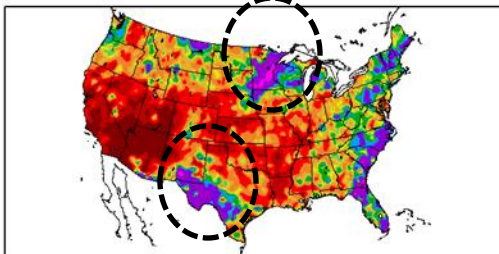
Percent of Normal Precipitation (%)
4/1/2012 – 4/30/2012



Generated 5/1/2012 at HPRCC using provisional data.

Regional Climate Centers

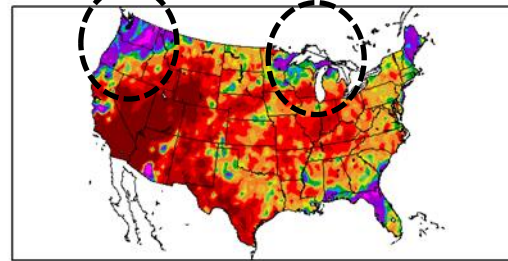
Percent of Normal Precipitation (%)
5/1/2012 – 5/31/2012



Generated 6/1/2012 at HPRCC using provisional data.

Regional Climate Centers

Percent of Normal Precipitation (%)
6/1/2012 – 6/30/2012



Generated 7/12/2012 at HPRCC using provisional data.

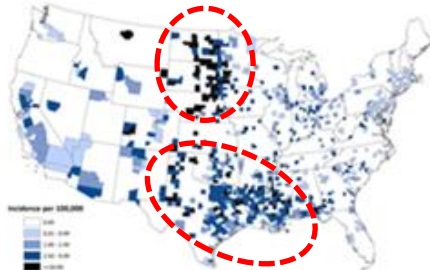
Regional Climate Centers

Maximum Temperature Anomaly from 1981–2010 Mean
July to September, 2012

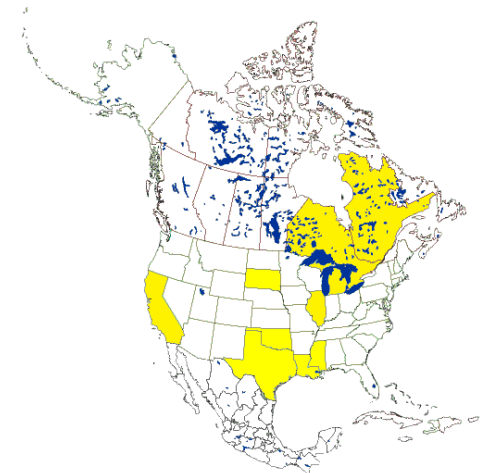
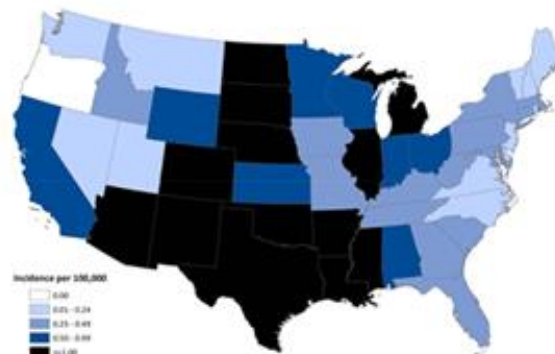


Degrees Fahrenheit
-18.0 -14.4 -10.8 -7.2 -3.6 0.0 3.6 7.2 10.8 14.4 18.0
-10 -5 -2 0 2 4 6 8 10
Degrees Celsius

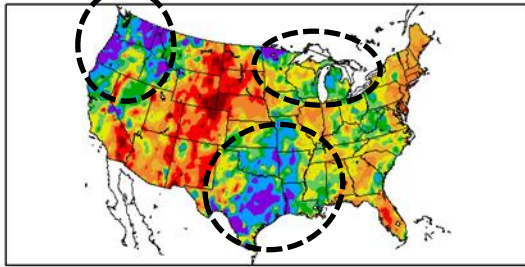
West Nile virus neuroinvasive disease incidence reported to ArboNET, by county, United States, 2012



West Nile virus neuroinvasive disease incidence reported to ArboNET, by state, United States, 2012



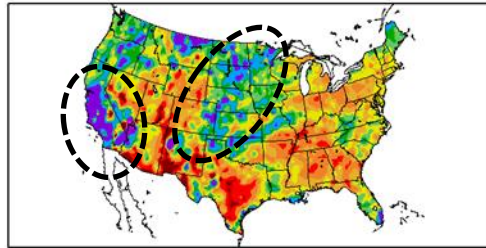
Percent of Normal Precipitation (%)
3/1/2012 – 3/31/2012



Generated 4/1/2012 at HPRCC using provisional data.

Regional Climate Centers

Percent of Normal Precipitation (%)
4/1/2012 – 4/30/2012



Generated 5/1/2012 at HPRCC using provisional data.

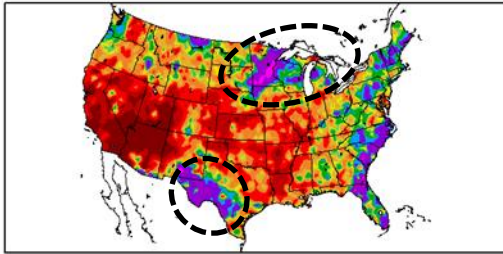
Regional Climate Centers

Maximum Temperature Anomaly from 1981–2010 Mean
July to September, 2012



Degrees Fahrenheit
-18.0 -14.4 -10.8 -7.2 -3.6 0.0 3.6 7.2 10.8 14.4 18.0
Degrees Celsius
-10 -8 -6 -4 -2 0 2 4 6 8 10

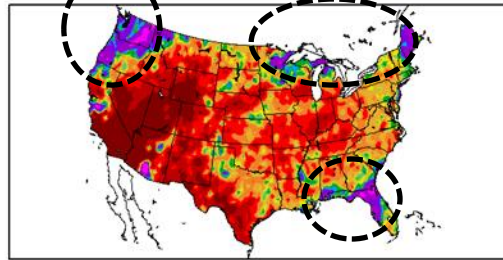
Percent of Normal Precipitation (%)
5/1/2012 – 5/31/2012



Generated 6/1/2012 at HPRCC using provisional data.

Regional Climate Centers

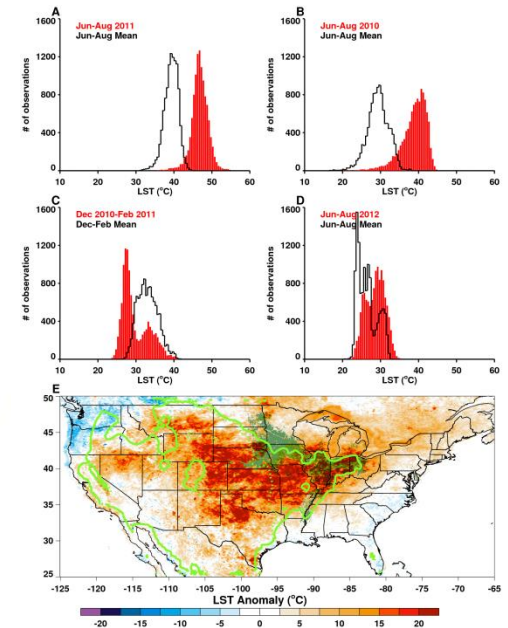
Percent of Normal Precipitation (%)
6/1/2012 – 6/30/2012



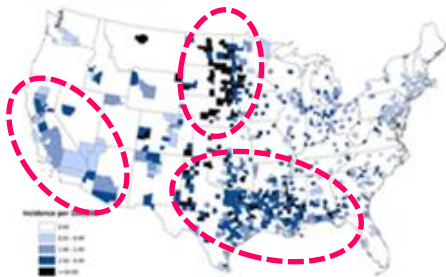
Generated 7/12/2012 at HPRCC using provisional data.

Regional Climate Centers

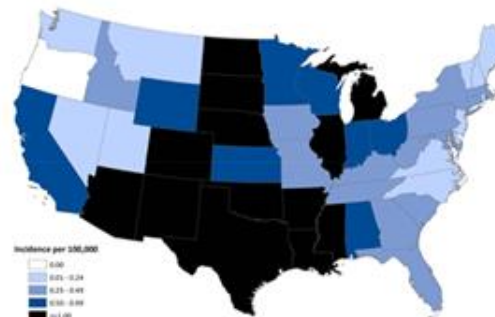
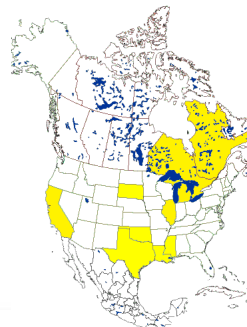
2012



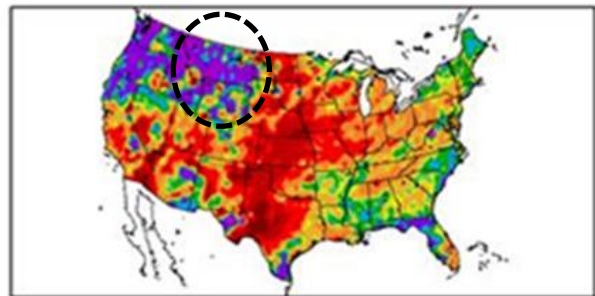
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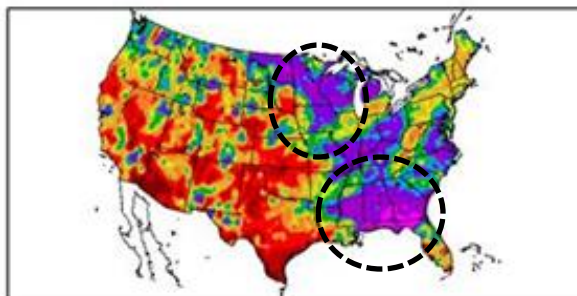
Percent of Normal Precipitation (%)
3/1/2014 - 3/31/2014



Generated 4/2/2014 at HPRCC using provisional data.

Regional Climate Centers

Percent of Normal Precipitation (%)
4/1/2014 - 4/30/2014

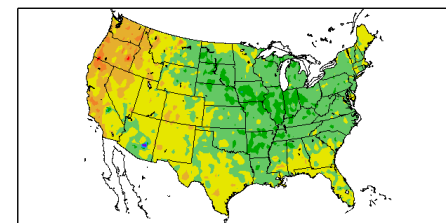


Generated 5/2/2014 at HPRCC using provisional data.

Regional Climate Centers

2014

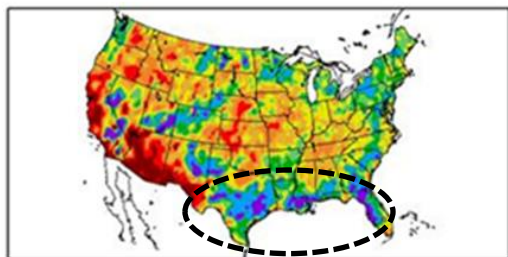
Departure from Normal Temperature (F)
7/1/2014 - 9/30/2014



Generated 10/2/2014 at HPRCC using provisional data.

Regional Climate Centers

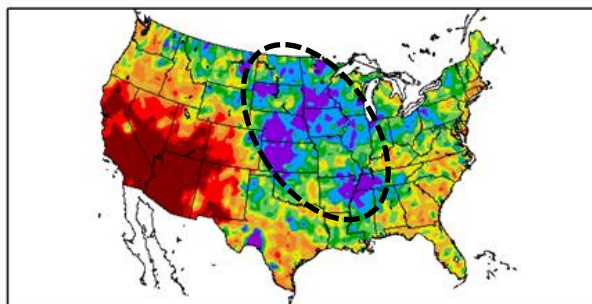
Percent of Normal Precipitation (%)
5/1/2014 - 5/31/2014



Generated 6/2/2014 at HPRCC using provisional data.

Regional Climate Centers

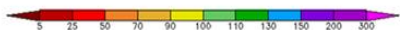
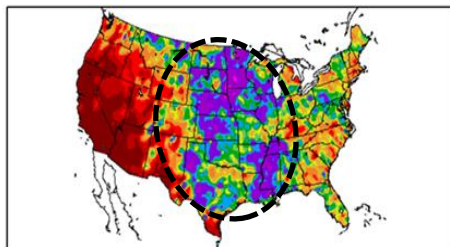
Percent of Normal Precipitation (%)
6/1/2014 - 6/30/2014



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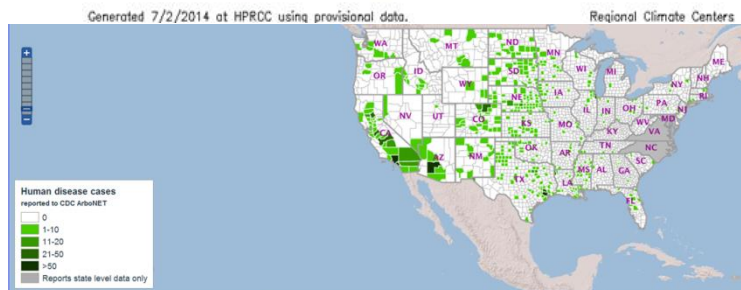
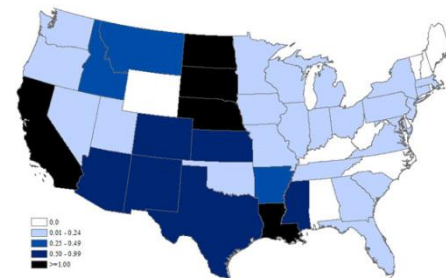
Regional Climate Centers

Percent of Normal Precipitation (%)
5/25/2014 - 6/23/2014



Generated 6/24/2014 at HPRCC using provisional data.

Regional Climate Centers

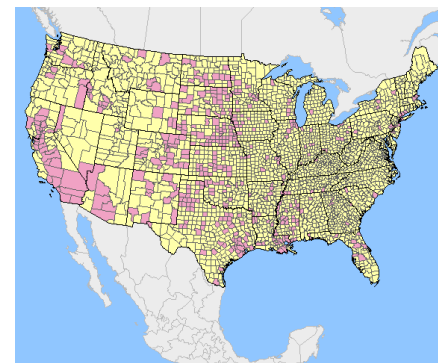


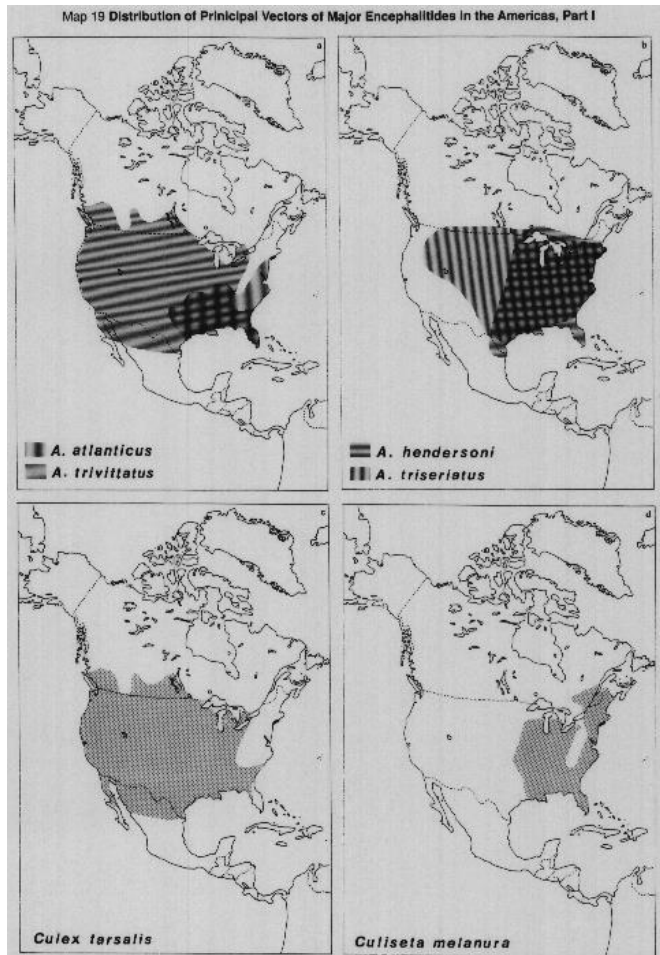
USA cumulative human disease cases reported to CDC ArboNET for 2014: 1935 disease cases

[Click to float Epi Curve](#)



Information From CDC Surveillance data from Public Health Agency of Canada

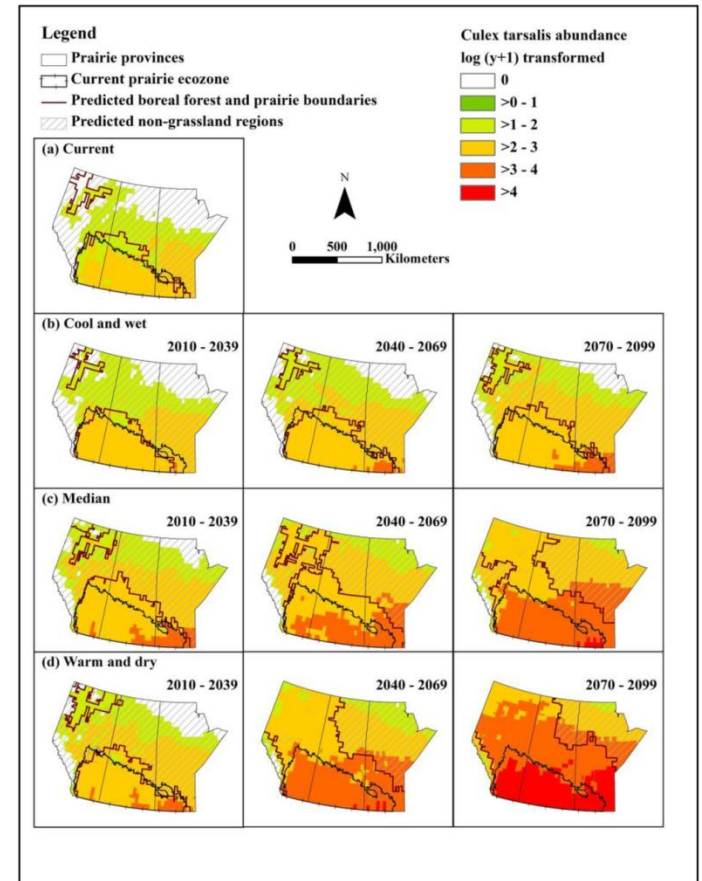




WNV

T+

P+



<http://www.ciesin.org/docs/001-613/001-613.html>

Chen et al. 2013

<http://www.mdpi.com/1660-4601/10/7/3052/htm>

World Health Organization (WHO). 1989. Geographical distribution of arthropod-borne diseases and their principal vectors. Report Number WHO/VBC/89.967. Geneva: World Health Organization.