Infectious Diseases & Climate Change

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March 3, 2021

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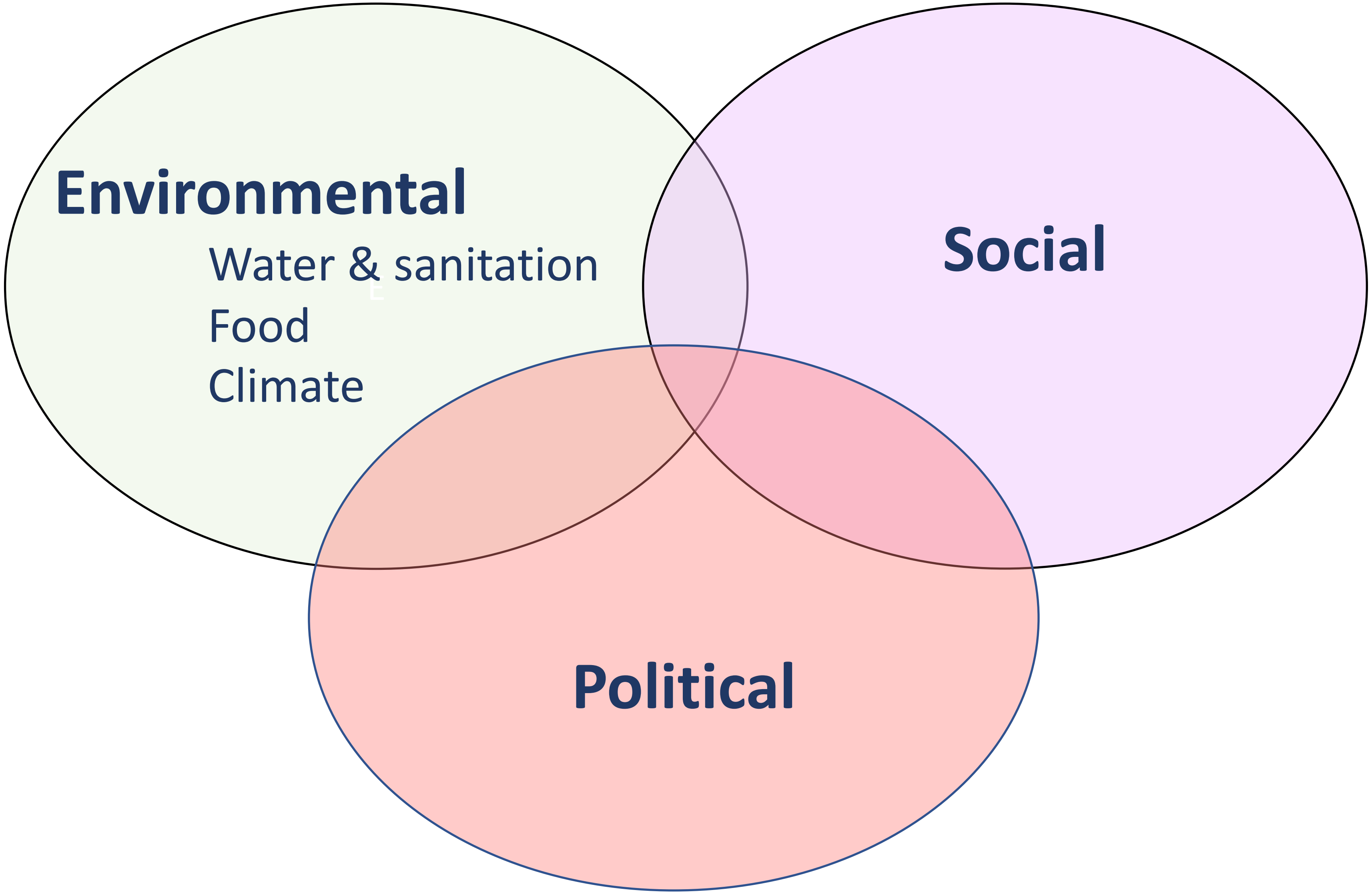
Factors that influence transmission of infectious diseases



How climate change may affect emergence and re-emergence of infectious diseases

- Emerging infectious diseases are those whose incidence in humans has increased in the past 20 years or those that threaten to increase in the near future
- Can you think of some examples?
- SARS-CoV-2, SARS-CoV, MERS-CoV, Ebola, Zika, dengue, chikungunya

How climate change may affect emergence and re-emergence of infectious diseases

- What factors influence the (re-)emergence of infectious diseases?
- Genetic adaptation of pathogen to allow for human infection (species jump), improved pathogen and/or vector survival, changes in zoonotic reservoir abundance, changes in human host exposure or susceptibility

Environmental
Climate – direct effects

Social
Globalization

Political
Public health policies

Climate – indirect effects

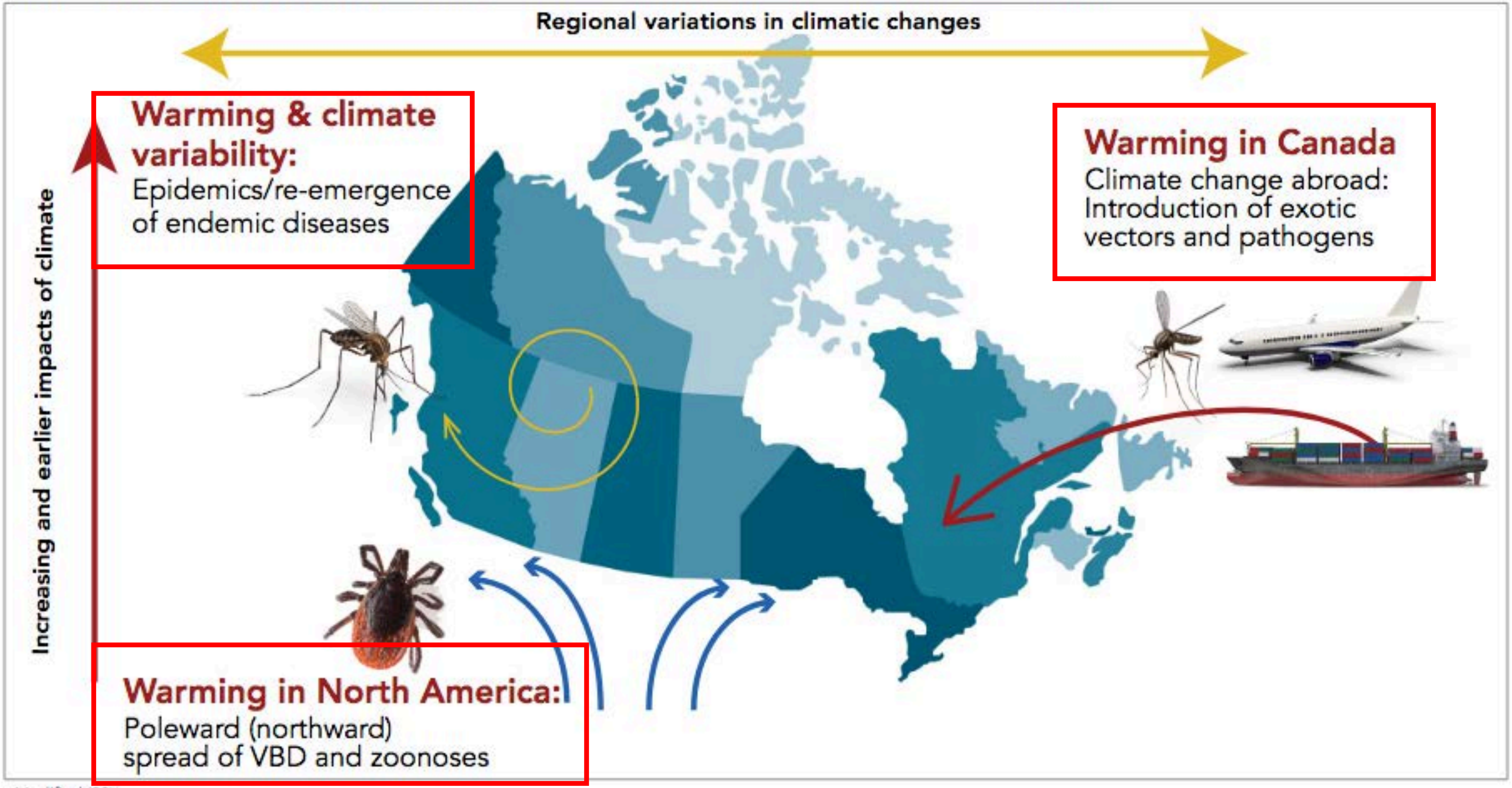
Ogden NH, Gachon P. Climate change and infectious diseases: What can we expect? Can Commun Dis Rep 2019;45(4):76–80.

Climate change is expected to:

1. Increase risk for the introduction and transmission of infectious diseases from around the world (COVID-19)
2. Spread of diseases currently endemic to only parts of North America (Lyme Disease)
3. Re-emergence of endemic infectious diseases (more epidemics, larger range) (West Nile Virus)

Ogden NH, Gachon P. Climate change and infectious diseases: What can we expect? Can Commun Dis Rep 2019;45(4):76–80.

Figure 3: A summary of climate change effects on infectious disease risks for Canada[a]

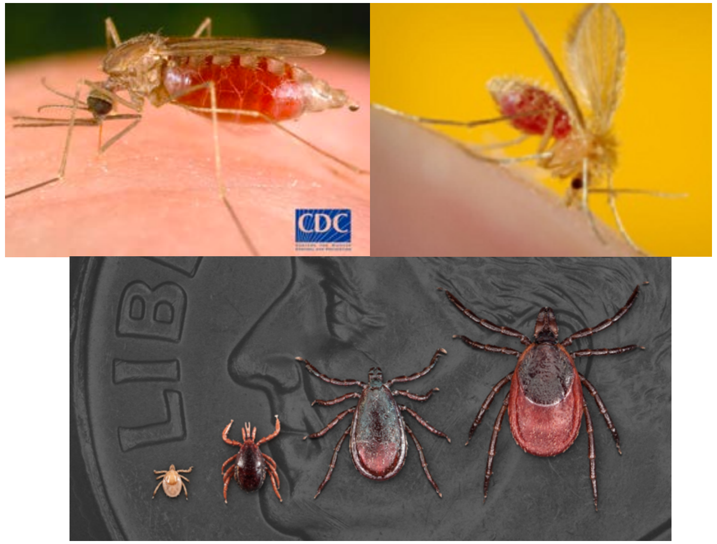


[a] Modified (23)

Ogden NH, Gachon P. Climate change and infectious diseases: What can we expect? Can Commun Dis Rep 2019;45(4):76–80.

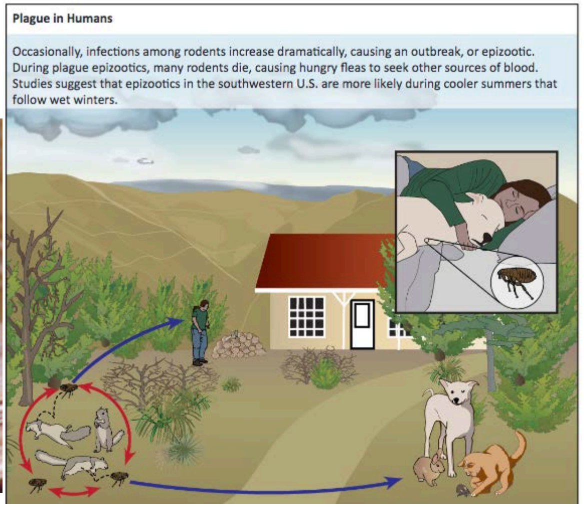
Climate impact on infectious diseases

Vector borne



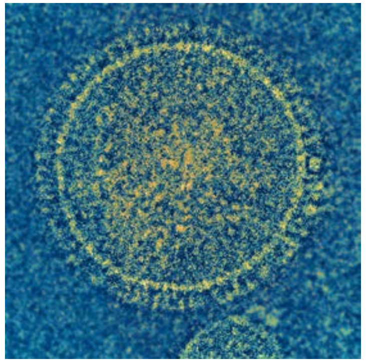
Water borne

Zoonoses



Respiratory infections

Influenza



RSV

The Endothermy Barrier

JCI The Journal of Clinical Investigation

Climate change brings the specter of new infectious diseases

Arturo Casadevall

J Clin Invest. 2020;130(2):553-555. https://doi.org/10.1172/JCI135003.

Viewpoint

The Endothermy Barrier

Clinical Infectious Diseases

MAJOR ARTICLE

IDSA Infectious Diseases Society of America · hivma hiv medicine association · OXFORD

Simultaneous Emergence of Multidrug-Resistant *Candida auris* on 3 Continents Confirmed by Whole-Genome Sequencing and Epidemiological Analyses

Shawn R. Lockhart,[1] Kizee A. Etienne,[1] Snigdha Vallabhaneni,[1] Joveria Farooqi,[4] Anuradha Chowdhary,[6] Nelesh P. Govender,[7] Arnaldo Lopes Colombo,[8] Belinda Calvo,[9] Christina A. Cuomo,[2] Christopher A. Desjardins,[2] Elizabeth L. Berkow,[1] Mariana Castanheira,[3] Rindidzani E. Magobo,[7] Kauser Jabeen,[4] Rana J. Asghar,[5] Jacques F. Meis,[10,11] Brendan Jackson,[1] Tom Chiller,[1] and Anastasia P. Litvintseva[1]

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OPINION/HYPOTHESIS
Host-Microbe Biology

Check for updates

On the Emergence of *Candida auris*: Climate Change, Azoles, Swamps, and Birds

Arturo Casadevall,[a] Dimitrios P. Kontoyiannis,[b] Vincent Robert[c]

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[b]Division of Internal Medicine, The University of Texas MD Anderson Cancer Center, Houston, Texas, USA
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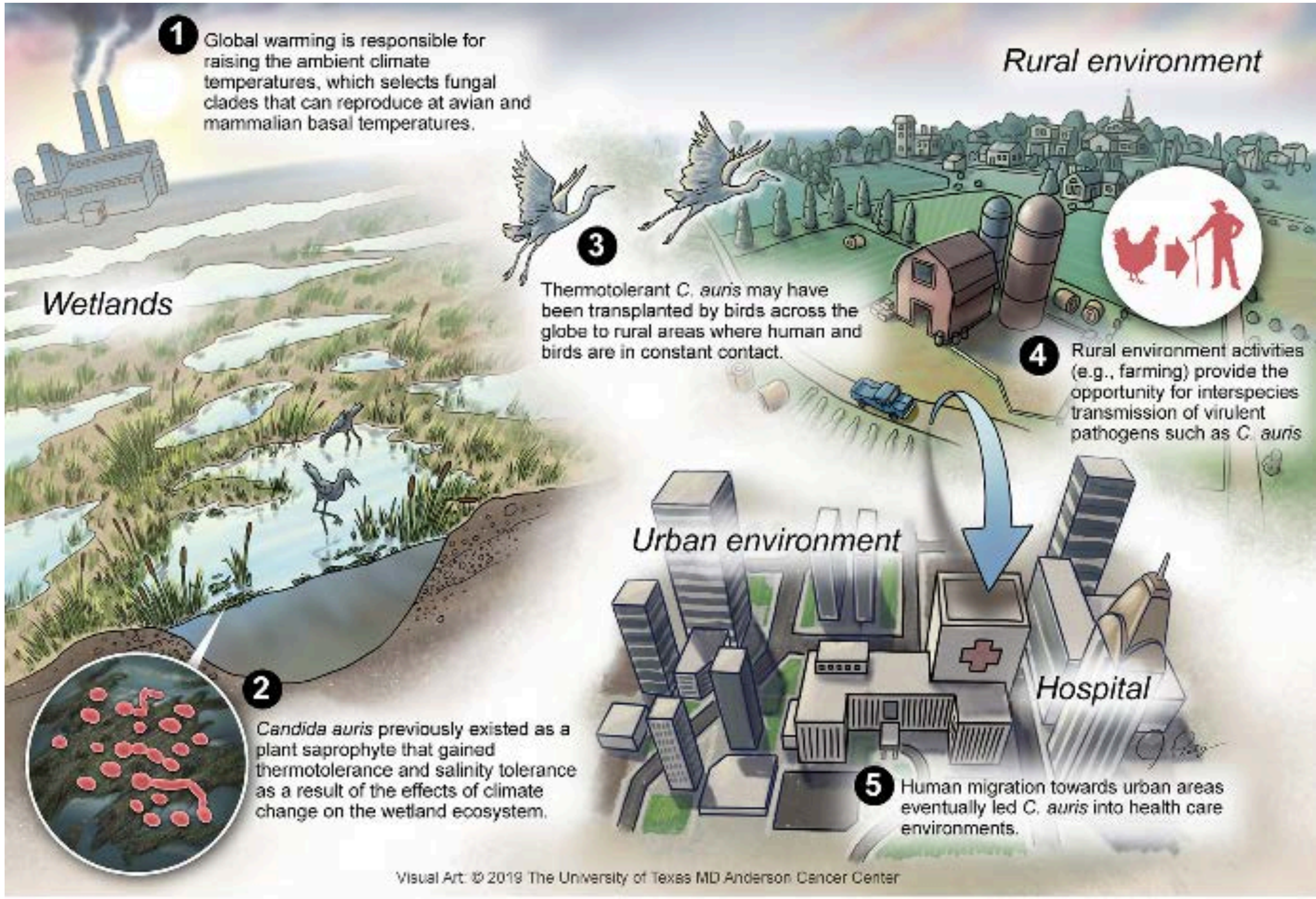

FIG 2 Proposed scheme for the emergence of *C. auris*.

Vector borne diseases and climate change in Ohio

1) Tickborne: Lyme Disease

2) Mosquito-borne: West Nile Virus

Zoonotic Disease Program
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Tickborne Diseases in Ohio

June 20, 2019 | ODH

Diseases spread by ticks are an increasing concern in Ohio and are being reported to the Ohio Department of Health more frequently in the past decade, with Lyme disease and Rocky Mountain spotted fever (RMSF) being the most common. Other tickborne diseases such as anaplasmosis, babesiosis and ehrlichiosis are also on the rise. Though rare, diseases such as tularemia, southern tick-associated rash illness (STARI) and Powassan virus may also be carried by Ohio ticks.

The Zoonotic Disease Program tracks and responds to tickborne diseases. We collect and analyze data to detect trends in disease activity, investigate reported cases of tickborne diseases, collaborate with other state agencies and educate Ohioans about disease risks and prevention strategies.

Prevent tick bites | Ticks in Ohio | Frequently Asked Questions

There are about a dozen species of ticks that have been identified in Ohio. However, most species are associated with wild animals and are rarely encountered by people. Three species, the American dog tick, the blacklegged tick and the lone star tick, are among the most likely ticks to be encountered by people or pets and are described below. All three of these species are of significant public health importance and are responsible for nearly all tickborne

Common ticks found in Ohio
From left to right: blacklegged tick nymph, blacklegged tick female, blacklegged tick male, American dog tick female

Additional Downloads

Tick Identification Card

Bookmark: Be Tick Smart

Lyme Disease
Rocky Mountain Spotted Fever
Anaplasmosis
Ehrlichiosis
Babesiosis

Local spread of vector-borne diseases: Lyme disease

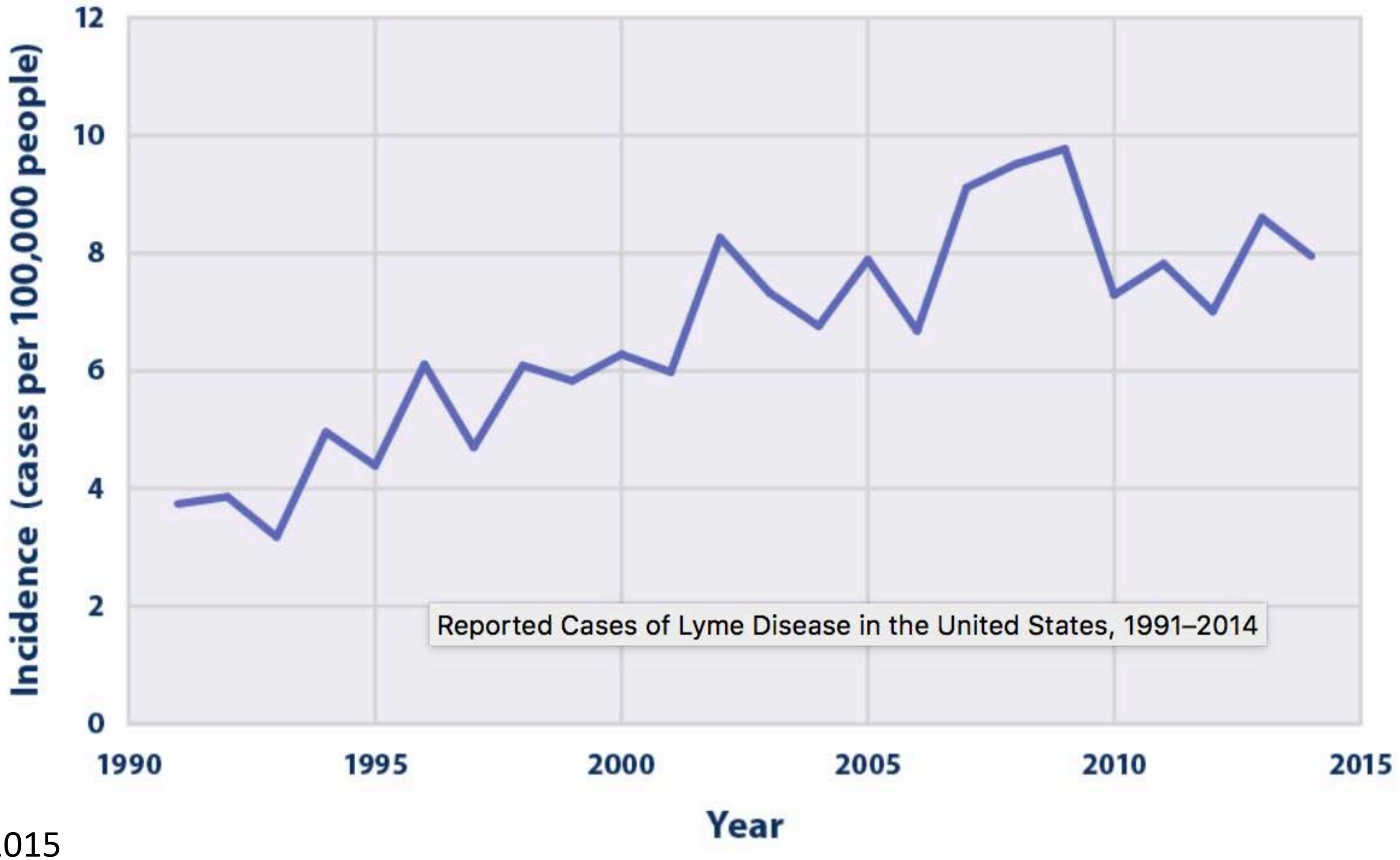
Lyme disease caused by bacteria *Borrelia burgdorferi*

Early symptoms of Lyme disease typically begin 3-30 days after a tick bite and can include:

- Erythema migrans rash
  ("bull's eye" rash)
- Headache
- Fever
- Chills
- Muscle pain
- Joint pain
- Fatigue

Incidence of Lyme Disease in US doubled from 1991 to 2014

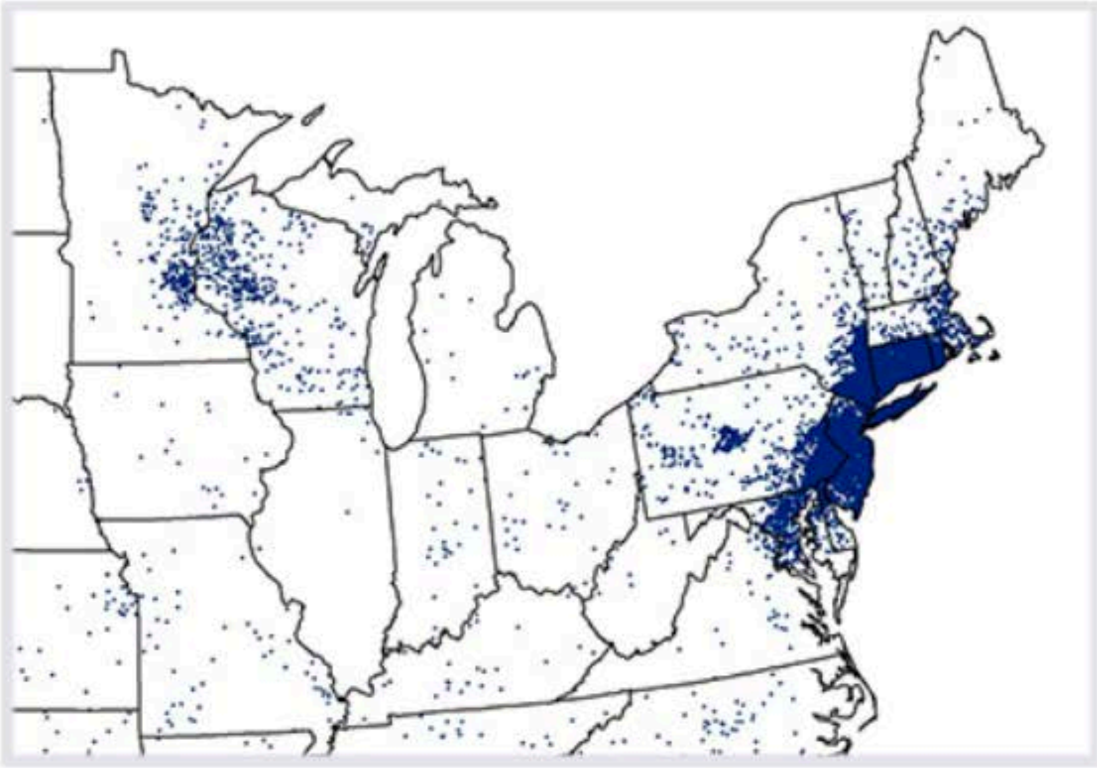
Figure 1. Reported Cases of Lyme Disease in the United States, 1991–2014



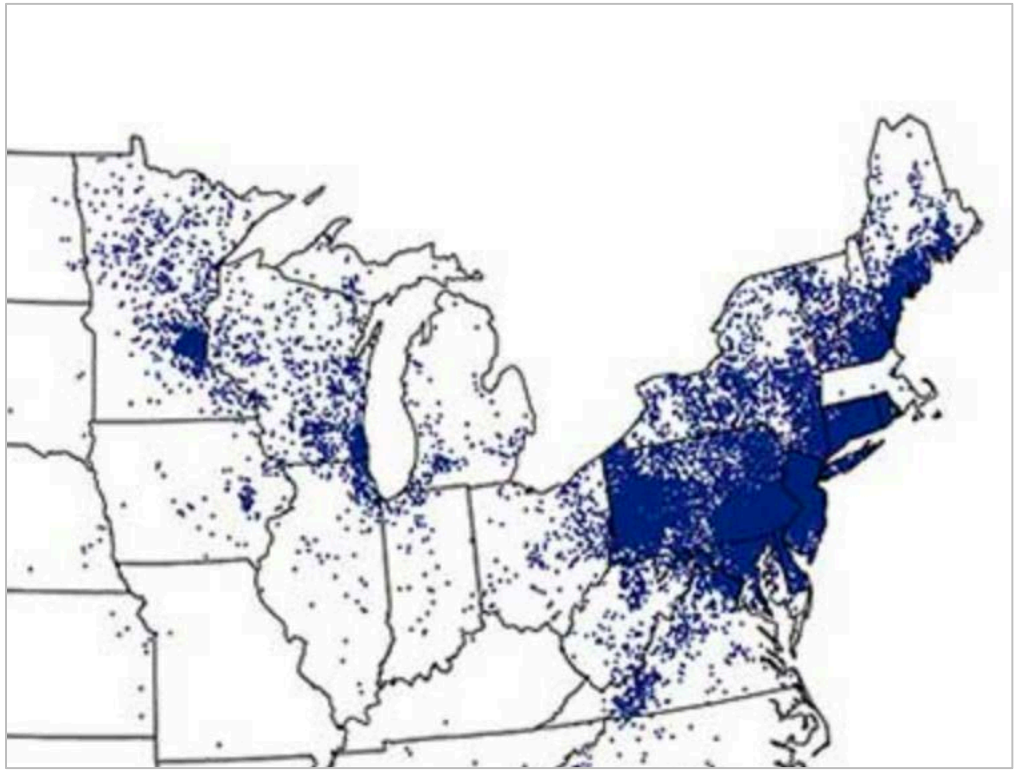
epa.gov, data source: CDC, 2015

Increasing incidence of Lyme Disease in the eastern US

Reported Lyme Disease Cases in 1996 and 2018



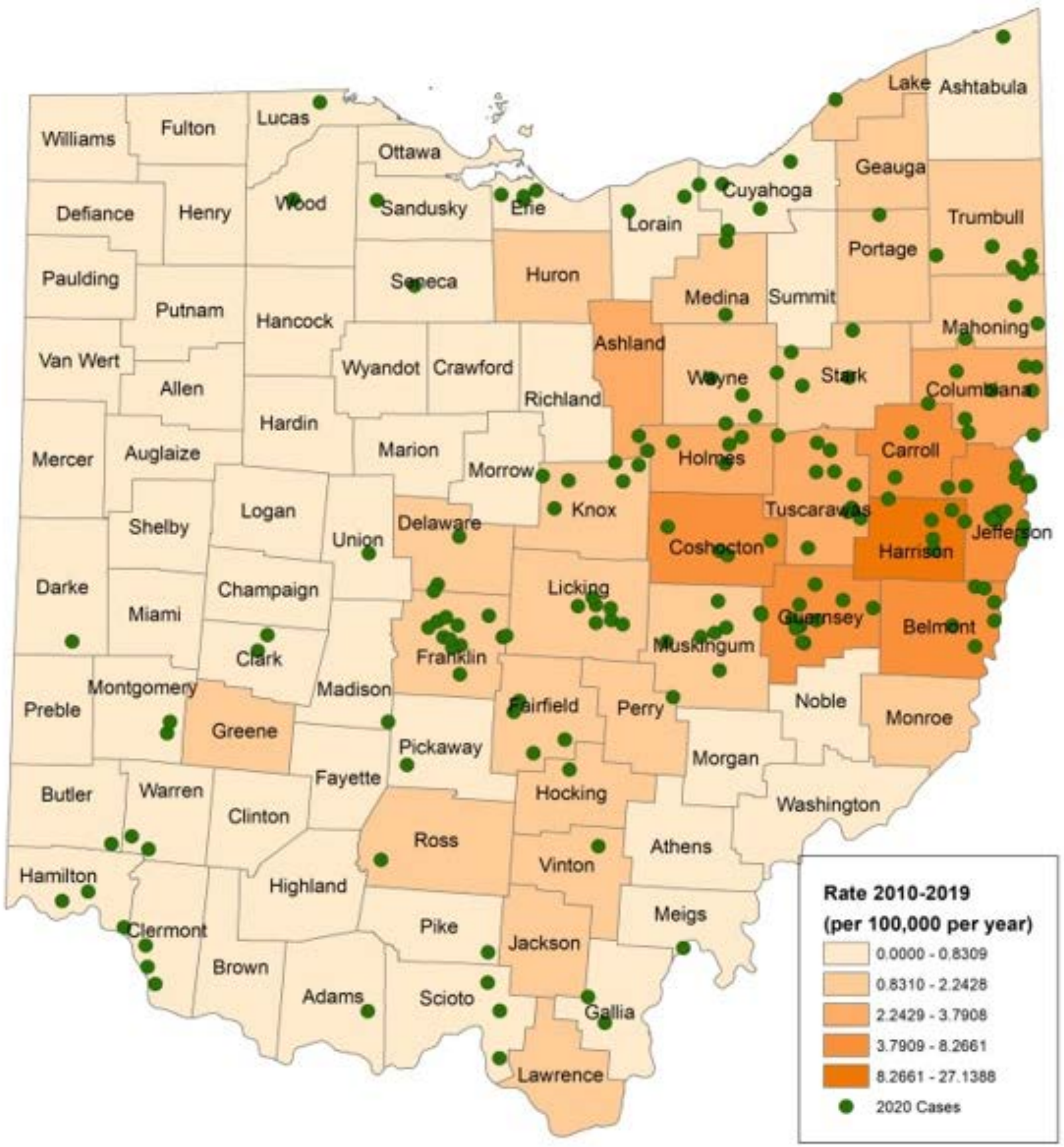
1996



2018

cdc.gov

Lyme Disease in Ohio
2020* Cases Compared to Incidence 2010 – 2019

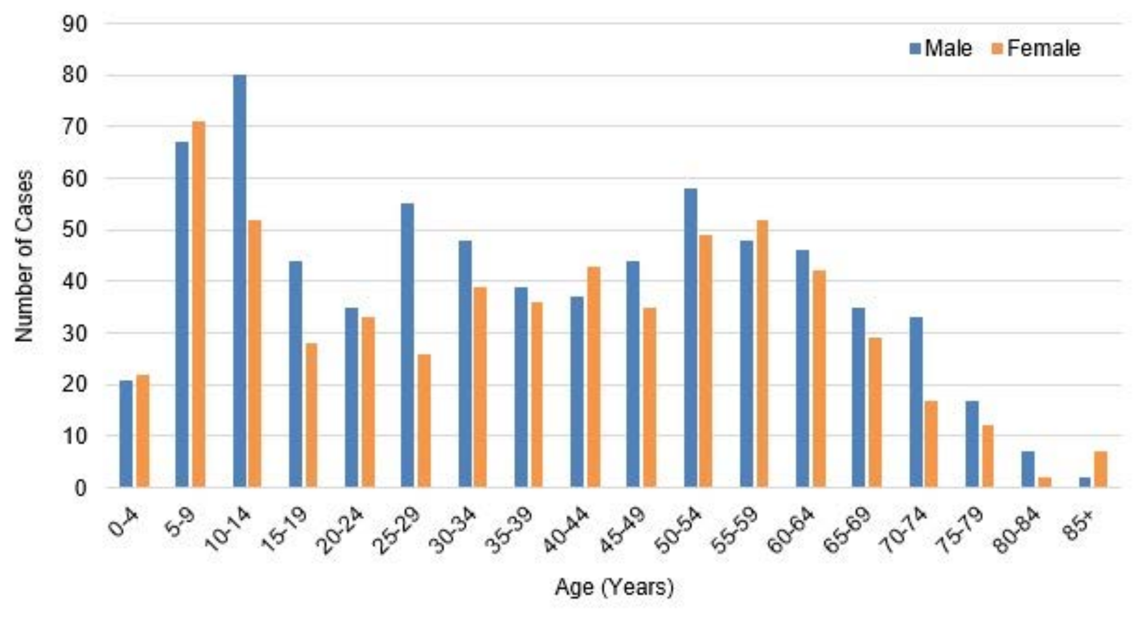


Source: Ohio Department of Health

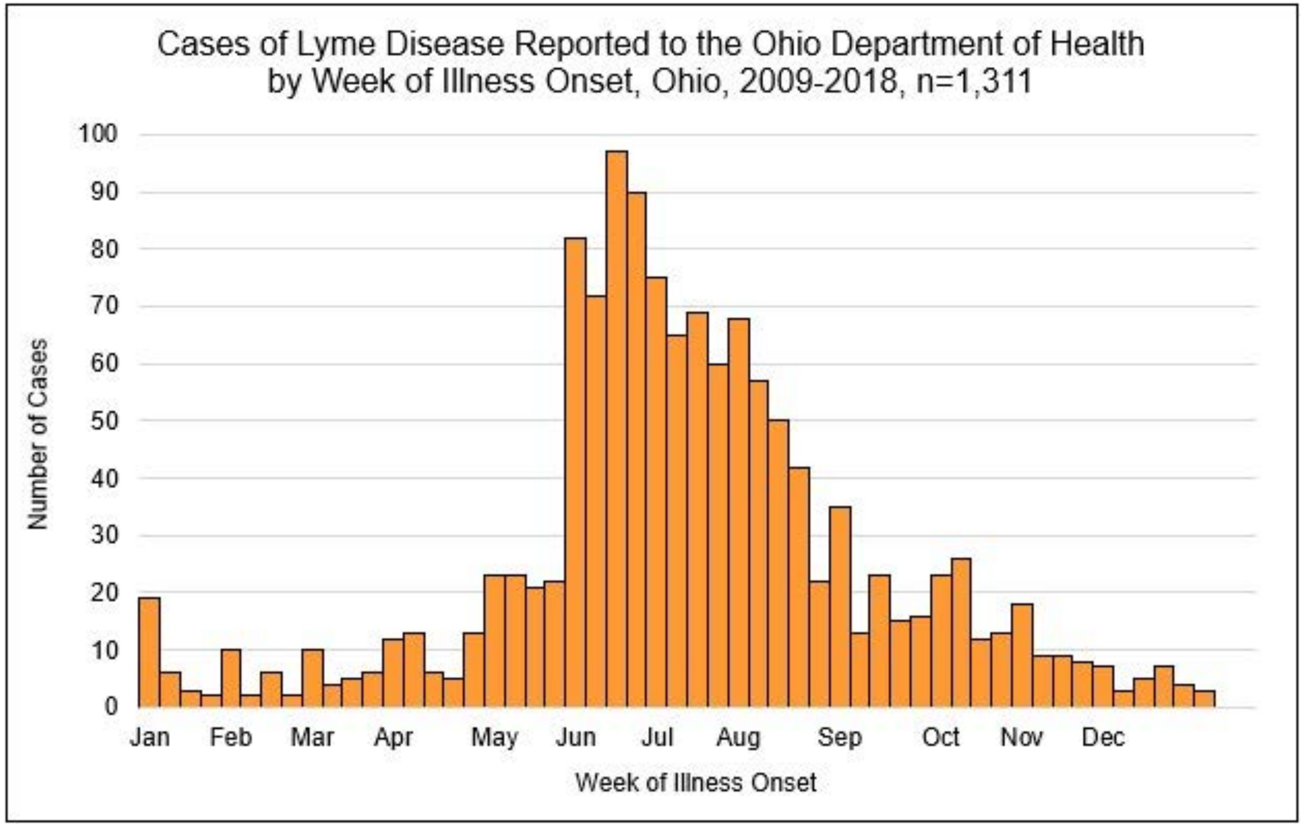
* Data as of 09/03/2020, 181 cases

County-level data are based on the county of residence of the case

Age Distribution of Lyme Disease Cases Reported to the Ohio Department of Health, 2009-2018, n=1,311



Ohio Lyme Disease Annual Case Statistics					
Year	Human Cases	Deaths	Median Age (Years)	Age Range of Cases (Years)	Counties with Reported Lyme Cases
2009	58	0	36.5	2-77	27
2010	44	0	34.5	3-62	24
2011	53	0	34	5-84	25
2012	67	0	33	3 - 86	30
2013	93	0	43	2 - 84	34
2014	119	0	35	1 - 78	32
2015	154	0	41	1 - 85	45
2016	160	0	37	3 - 85	40
2017	270	0	40	3-86	44
2018	293	0	33	1-90	50
AVG	131	0	37	n/a	35
TOTAL	1,063	0	n/a	n/a	n/a

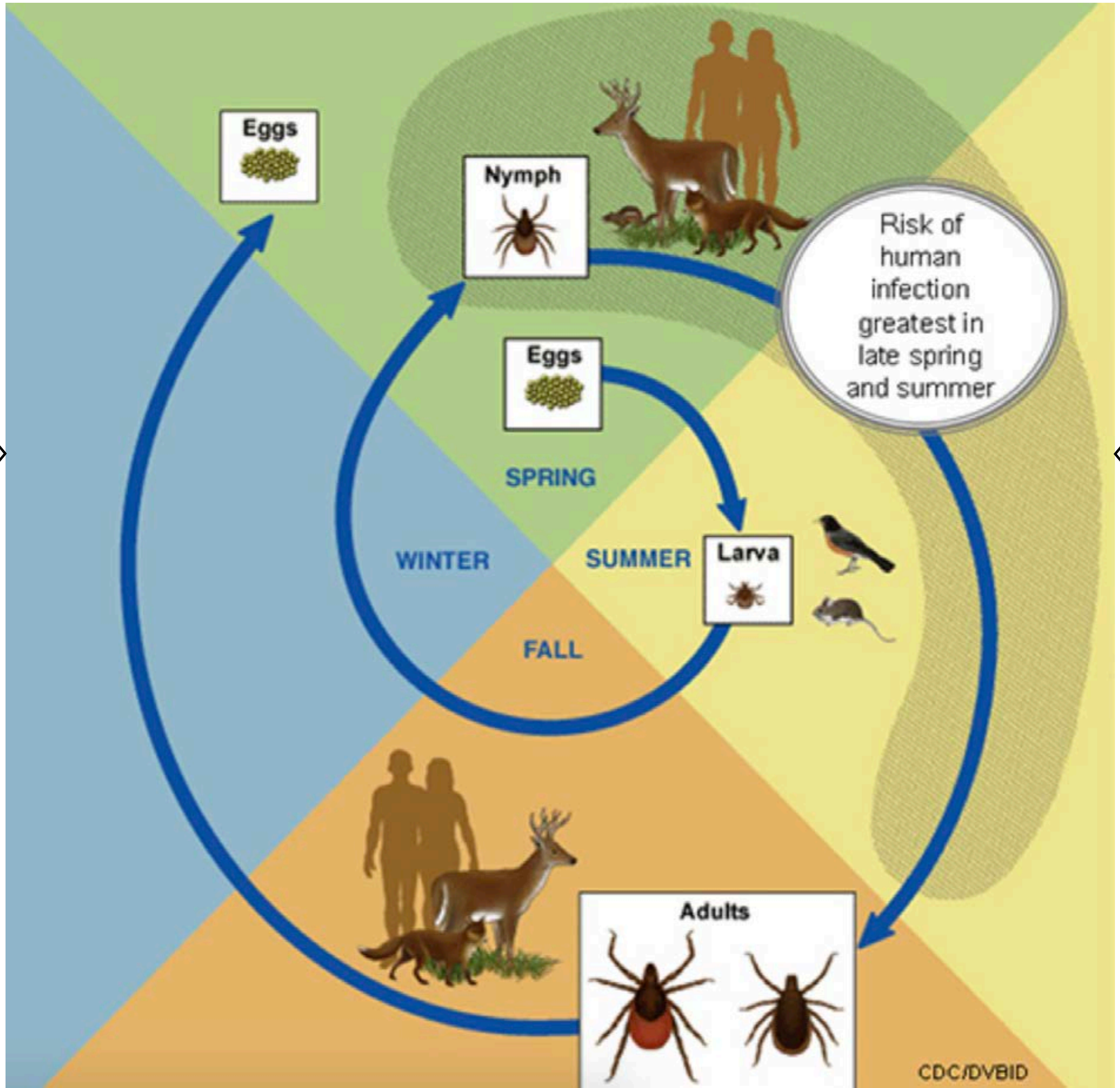


Mechanisms linking climate change to increased Lyme incidence

<u>Environmental & Institutional Context</u>

Changing ecosystems

Vector control & public health practices



<u>Social & Behavioral Context</u>

Social determinants of health

Outdoor activity

Beard et al, 2016, US Global Change Research Program, “The impacts of climate change on human health in the US”. https://health2016.globalchange.gov.

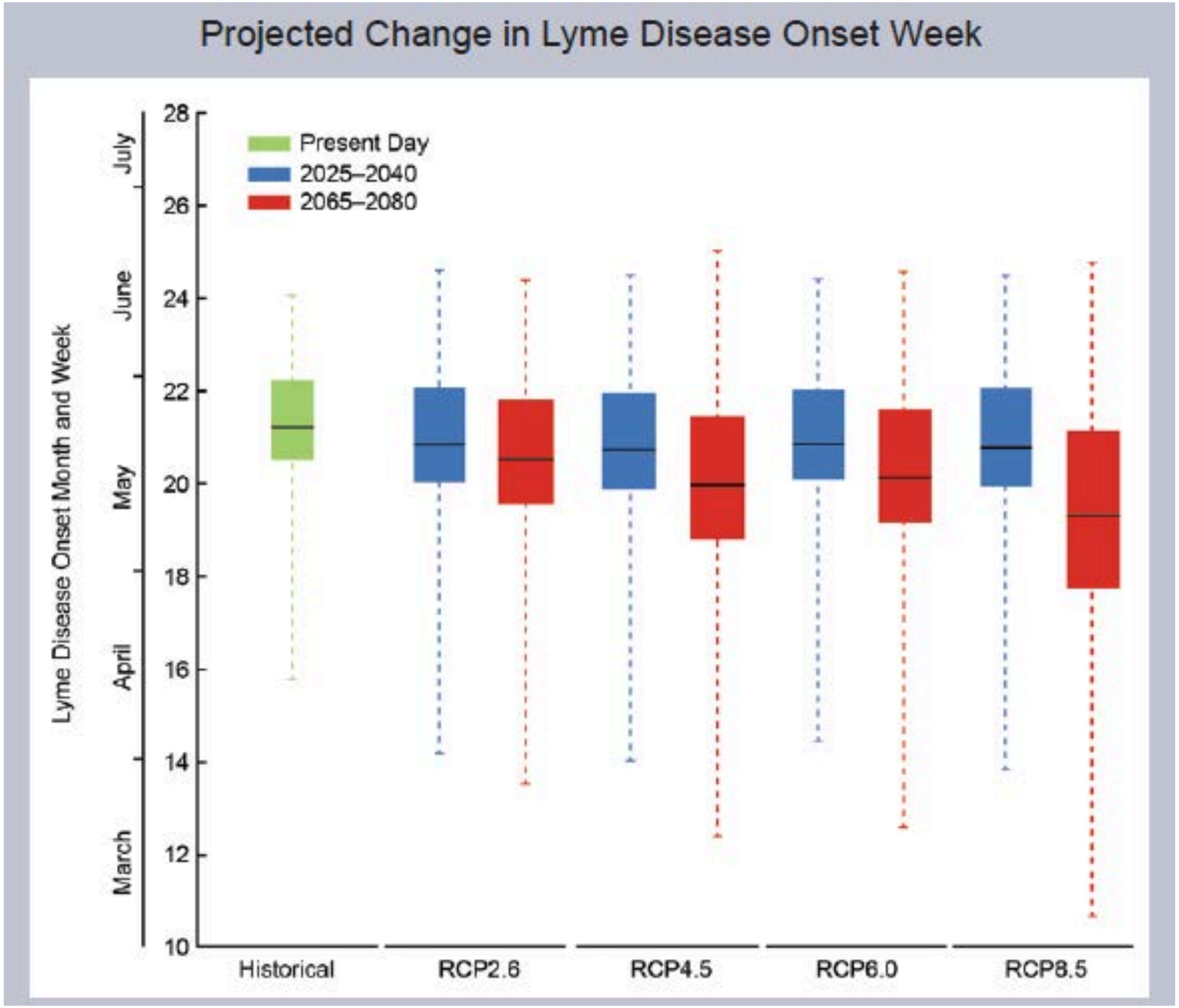
Mechanisms linking climate change to increased Lyme incidence

The potential for contracting Lyme disease depends on:

1. Tick vector abundance (especially density of host-seeking nymphs)
2. Prevalence of *B. burgdorferi* infection in ticks (especially the prevalence in nymphs)
3. Contact frequency between infected ticks and humans

To accurately project changes in Lyme disease risk based on climate variability, need **long-term data collection** on tick **vector abundance** and **case counts**

https://health2016.globalchange.gov.



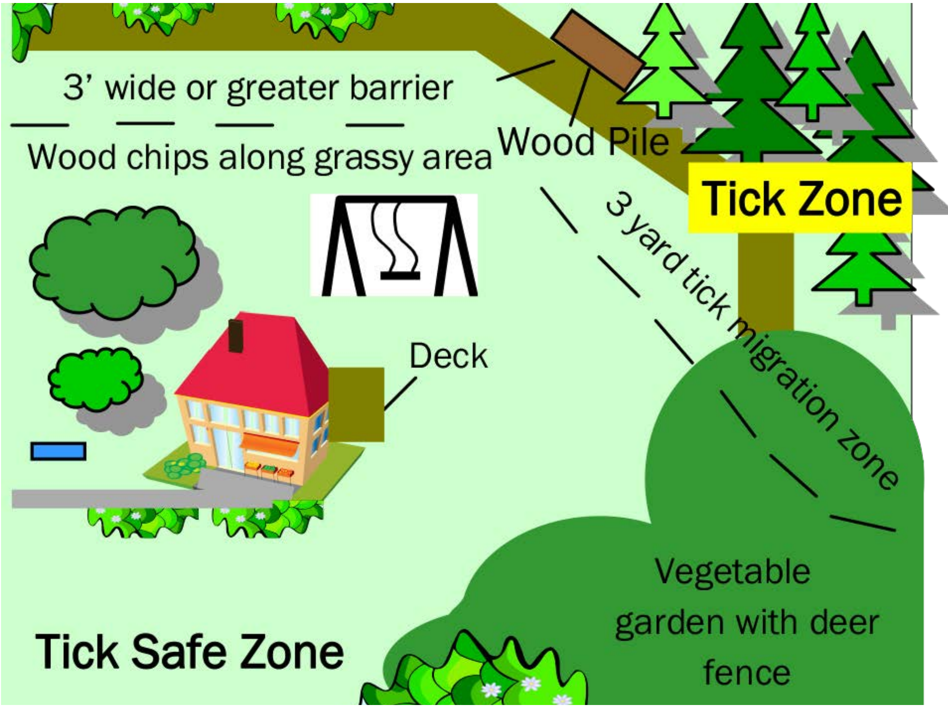
Monaghan et al 2015, *Ticks and Tick- Borne Diseases,* **6,** 615-622.

https://health2016.globalchange.gov

Possible solutions to Lyme disease problem

Prevent tick bites:

- Ticks live in grassy, brushy, and wooded areas
- DEET, permethrin-treated clothes and gear, long pants & sleeves
- Tick check (pets too), shower within 2hrs of coming indoors
- Landscaping techniques



Societal level:

- Improved insect repellant development
- CDC efforts: TickNET, state health depts, vector-borne disease Centers of Excellence, The Tick Project

THE TICK PROJECT

tickproject.org

Method #1. The Tick Control System®

The "Tick Control System", or TCS®, is a small box that attracts small mammals. When an animal enters the box, it receives a minute dose of fipronil, the active ingredient in many tick treatments used on dogs and cats. Fipronil kills ticks on animals like mice and chipmunks, which are largely responsible for infecting ticks with the Lyme bacterium.

Method #2. Met52® fungal spray

Metarhizium anisopliae is a fungus that occurs naturally in forest soils in eastern North America. It has been shown to kill ticks. A strain of this fungus, Met52, has been developed as a commercial product. It can be sprayed on vegetation where it kills ticks looking for hosts on which to feed.

The study will answer once and for all whether we can prevent cases of tick-borne disease by treating the areas around people's homes. If this approach prevents disease, we will be able to recommend plans that could be immediately adopted by local municipalities, governments, community groups, or neighborhoods.

Local spread of vector-borne diseases: West Nile Virus

Most common mosquito-borne disease in US

~1 in 5 people who are infected develop a fever and other symptoms.

~1 out of 150 infected people develop a serious, sometimes fatal, encephalitis/meningitis.

acvcsd.org

cdc.gov

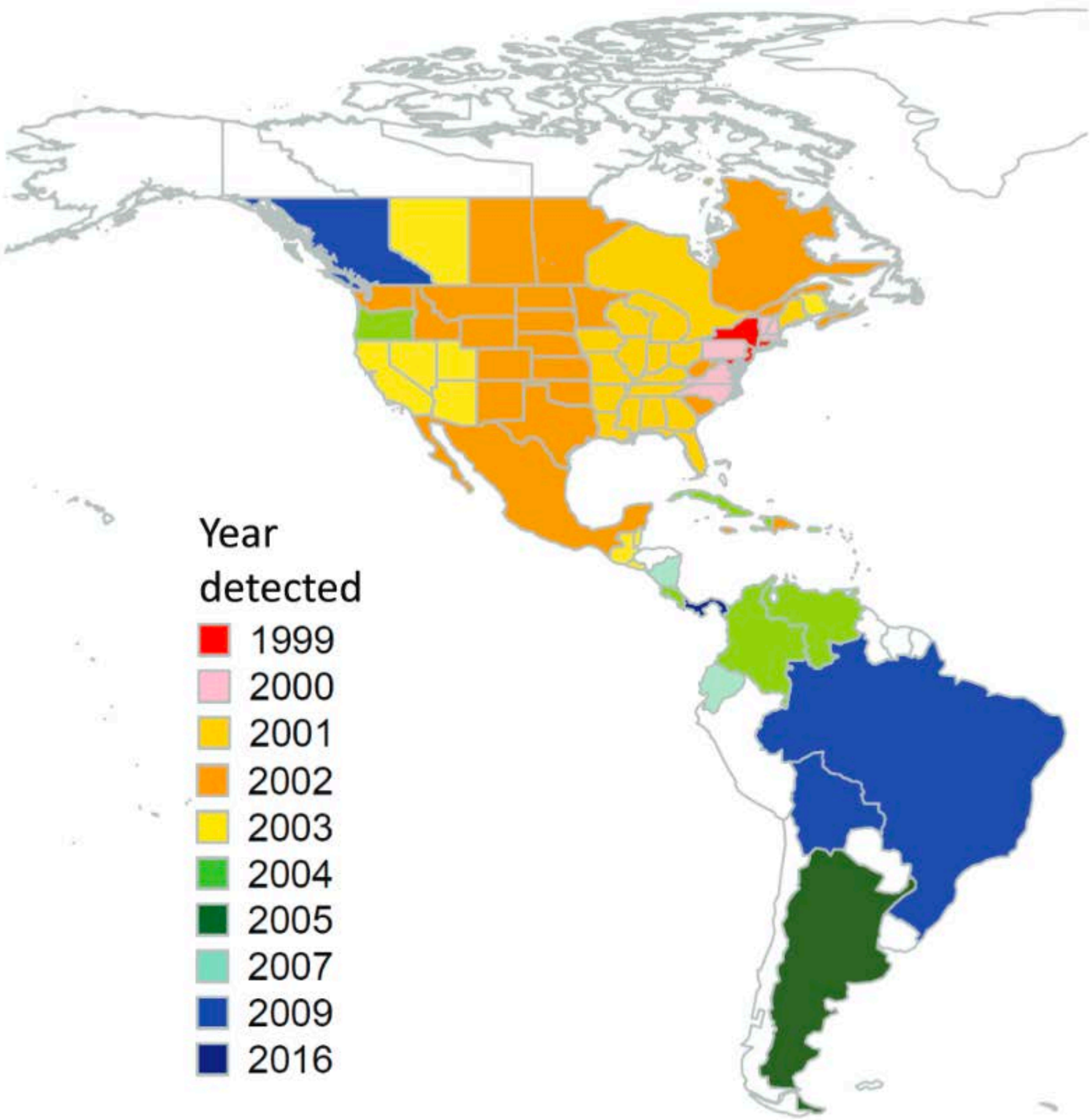


Fig. 1. Global distribution of WNV in the Americas. Color of the country, state, or province indicates the first year that WNV was detected. For several countries in the Americas no reports on the presence of WNV could be found, but the virus may be present (e.g., Peru, Chile, etc.).

Mechanisms linking climate to WNV transmission

Unlike ticks, mosquitoes have short life cycles and respond more quickly to climate drivers (days-weeks)

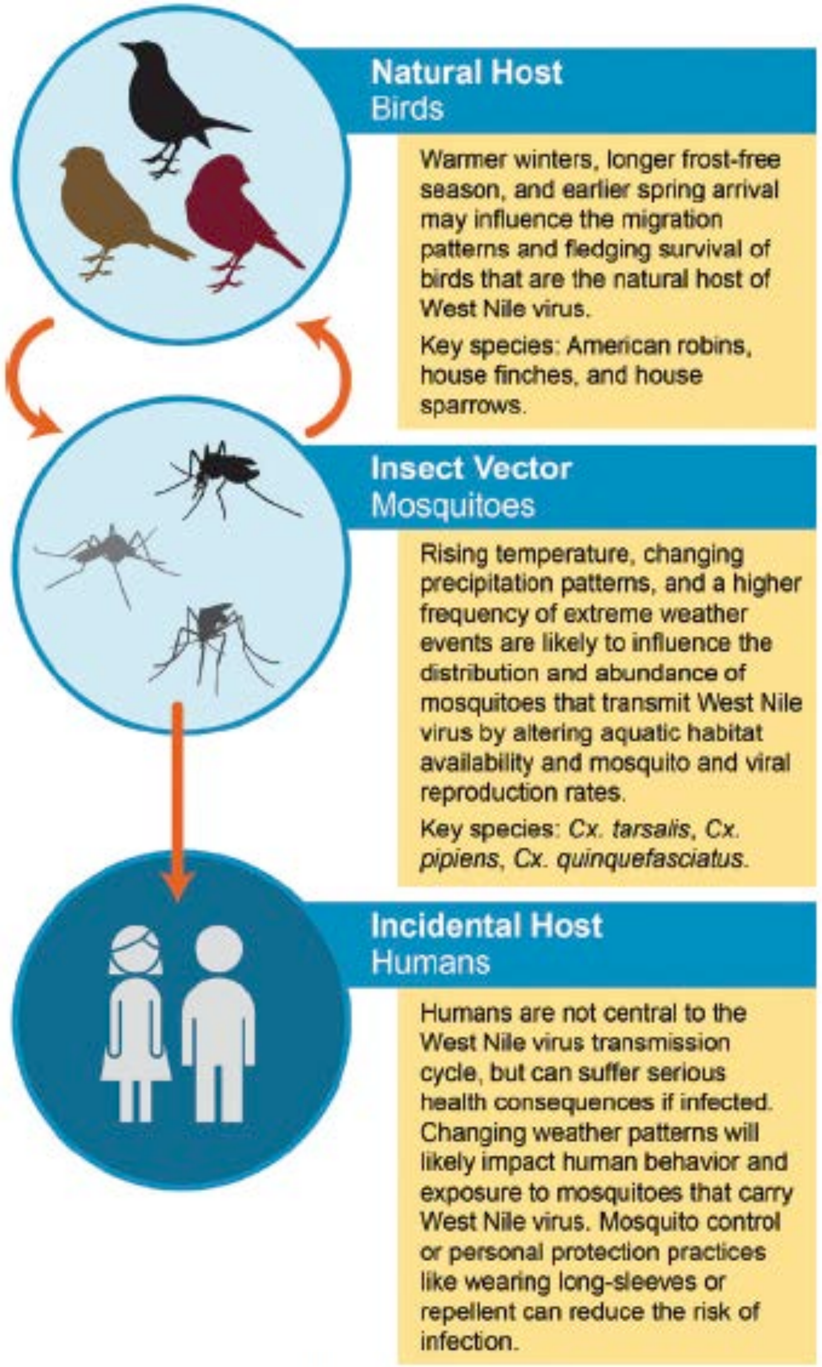


Figure 6: Climate Impacts on West Nile Virus Transmission

Warmer winters, earlier spring arrival influence migration and survival

Rising temp, changes in precipitation, extreme weather influence distribution & abundance of mosquito vector

Changing weather may influence human behavior and exposure to mosquito vector

https://health2016.globalchange.gov

Projecting changes in WNV transmission with climate change is challenging

- Data show links between key weather variables (temp & precipitation) and WNV transmission

- Projecting impact of climate change more challenging:
  - Short history in US
  - Geographical variation in the US in relationship between precipitation & WNV transmission (e.g. northern Great Plains vs. Pacific Northwest, urban vs. rural)
  - Complex transmission cycles

- Likely that **some segments of the population will be disproportionately affected** by or exposed to vector-borne diseases in response to climate change

Birds such as the house finch are the natural host of West Nile virus.

https://health2016.globalchange.gov

Incidence of West Nile Neuroinvasive Disease by County in the United States

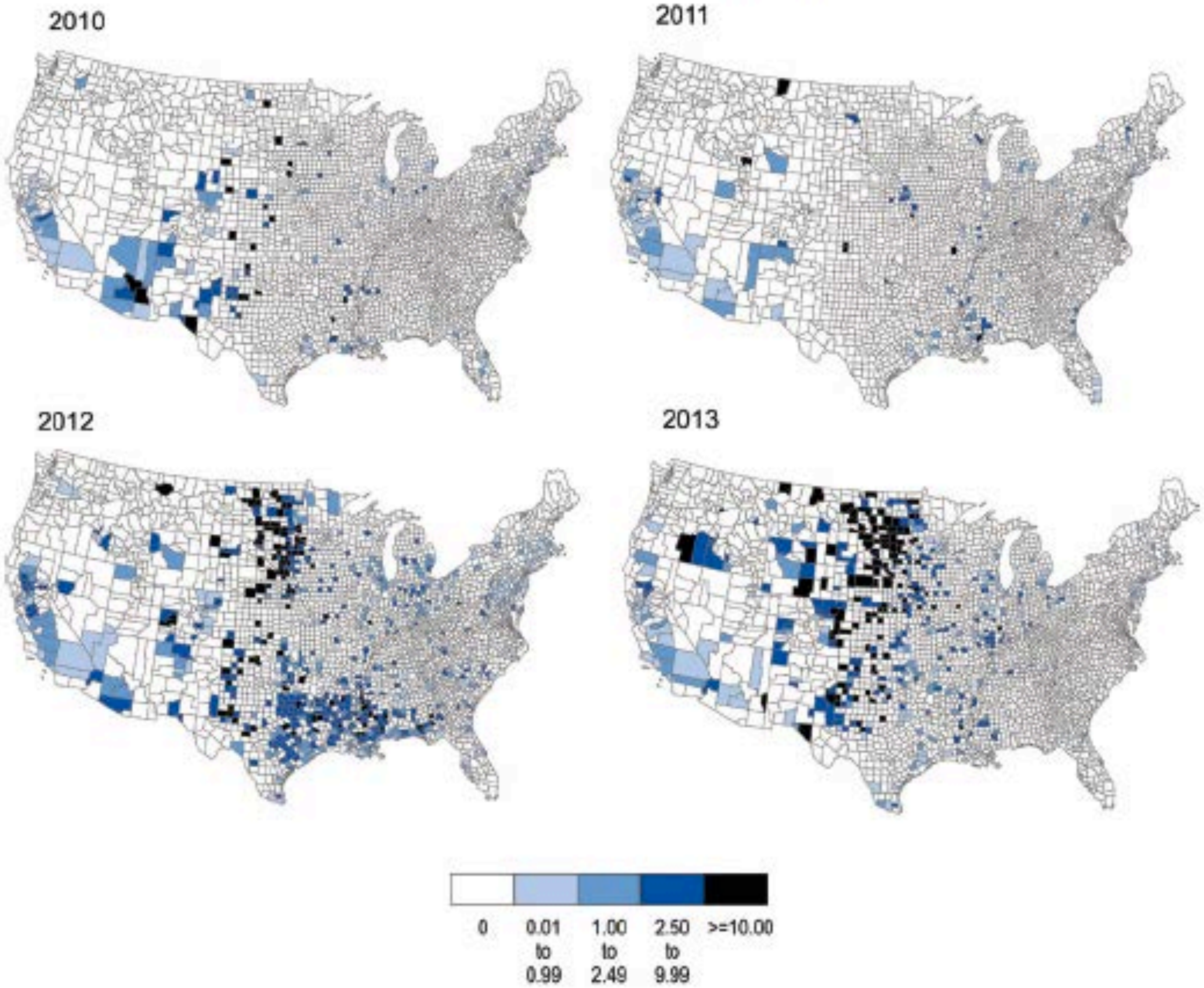
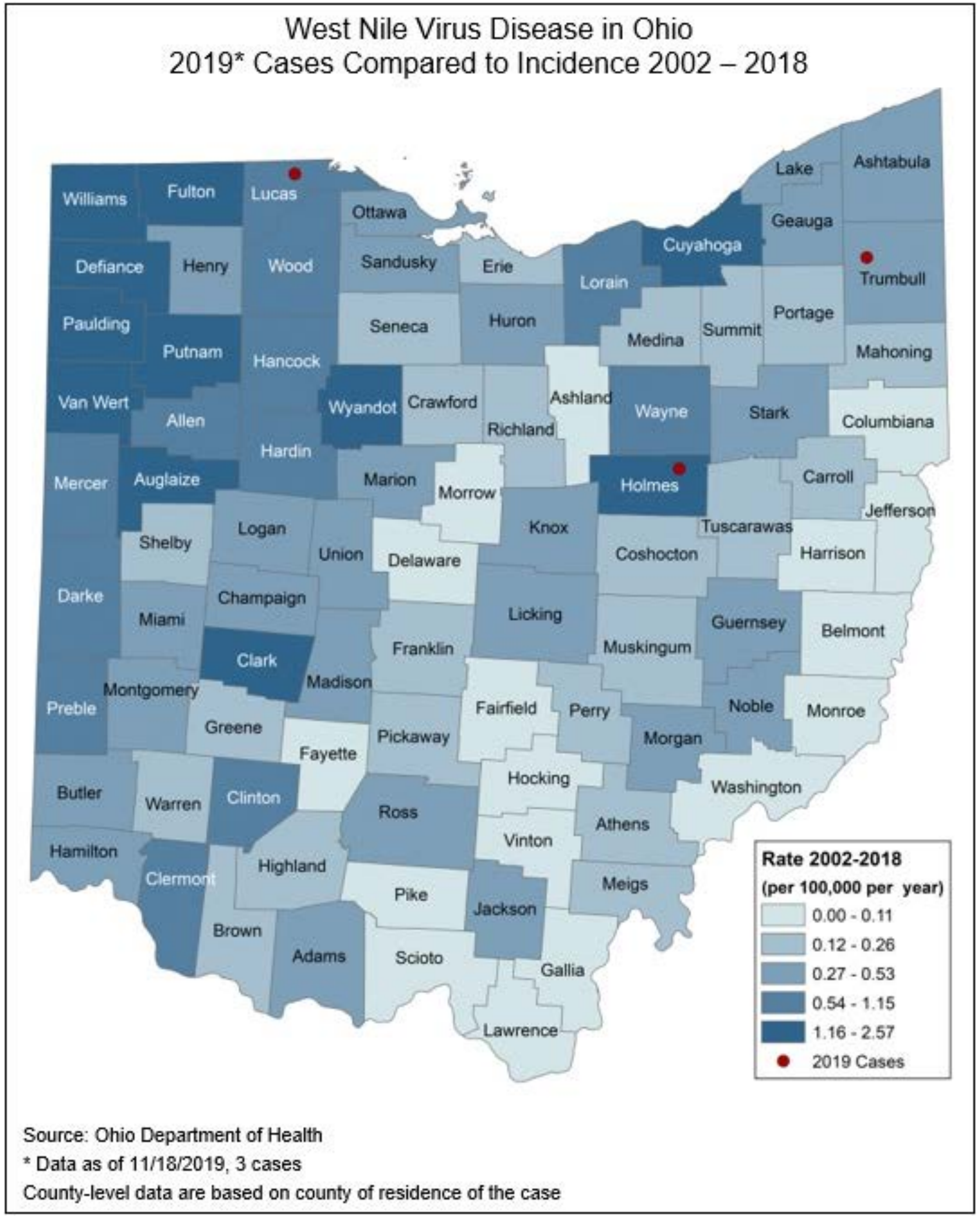
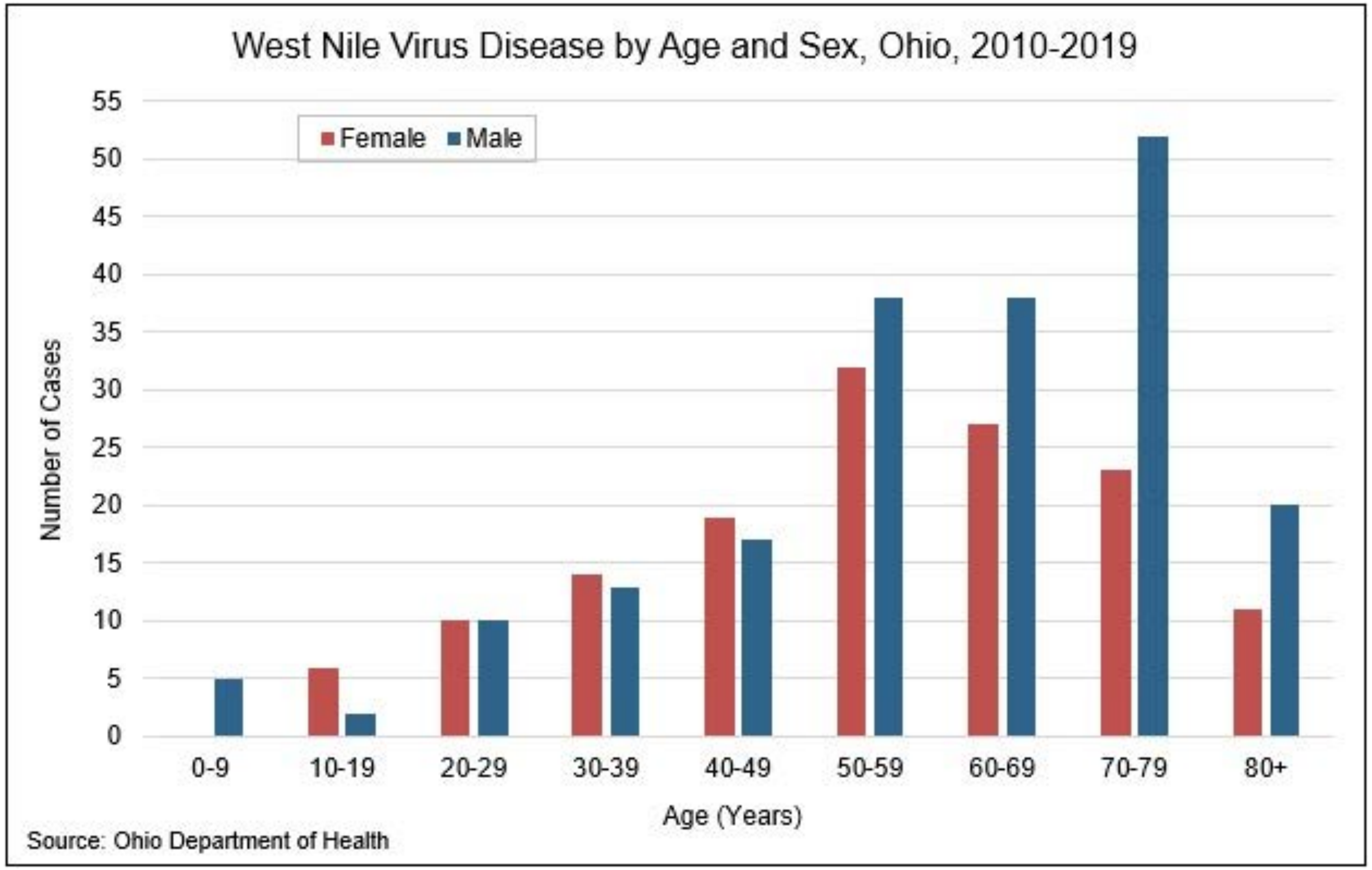


Figure 5: Maps show the incidence of West Nile neuroinvasive disease in the United States for 2010 through 2013. Shown as cases per 100,000 people. (Data source: CDC 2014)[73]

https://health2016.globalchange.gov


West Nile Virus Disease in Ohio
2019* Cases Compared to Incidence 2002 – 2018
Williams
Fulton
Lucas
Ottawa
Lake
Ashtabula
Geauga
Cuyahoga
Defiance
Henry
Wood
Sandusky
Erie
Lorain
Trumbull
Paulding
Putnam
Hancock
Seneca
Huron
Medina
Summit
Portage
Mahoning
Van Wert
Allen
Wyandot
Crawford
Ashland
Wayne
Stark
Columbiana
Richland
Hardin
Mercer
Auglaize
Marion
Morrow
Holmes
Carroll
Jefferson
Shelby
Logan
Union
Delaware
Knox
Tuscarawas
Coshocton
Harrison
Darke
Champaign
Licking
Miami
Guernsey
Belmont
Clark
Franklin
Muskingum
Madison
Montgomery
Preble
Fairfield
Perry
Noble
Monroe
Greene
Pickaway
Morgan
Fayette
Hocking
Washington
Butler
Warren
Clinton
Ross
Athens
Vinton
Hamilton
Clermont
Highland
Meigs
Pike
Jackson
Brown
Adams
Scioto
Gallia
Lawrence
Rate 2002-2018
(per 100,000 per year)
0.00 - 0.11
0.12 - 0.26
0.27 - 0.53
0.54 - 1.15
1.16 - 2.57
2019 Cases
Source: Ohio Department of Health
* Data as of 11/18/2019, 3 cases
County-level data are based on county of residence of the case


West Nile Virus Disease by Age and Sex, Ohio, 2010-2019
Female
Male
Number of Cases
55
50
45
40
35
30
25
20
15
10
5
0
0-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80+
Age (Years)
Source: Ohio Department of Health

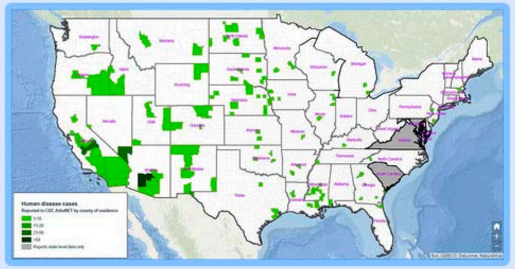
Ohio West Nile Virus Disease Annual Human Case Statistics						
Year	**Human Cases**	**Deaths**	**Median Age (Years)**	**Age Range of Cases (Years)**	**Earliest Date of Symptom Onset**	**Asymptomatic Blood Donors**
2001	0	0	n/a	n/a	n/a	n/a
2002	441	31	61	2 – 98	n/a	n/a
2003	108	8	49	11 – 90	n/a	6
2004	12	2	49.5	12 – 87	Jul 5	1
2005	61	2	53	22 – 96	Jun 14	14
2006	48	4	57.5	2 – 86	Aug 1	10
2007	23	3	52	11 – 86	Jul 12	9
2008	15	1	57	20 – 86	Jul 9	1
2009	2	0	36.5	11 – 62	Aug 27	0
2010	5	0	46	4 – 74	Jul 9	0
2011	21	1	55	14 – 83	Aug 1	6
2012	122	7	57.5	4 – 91	Jul 10	13
2013	24	4	71.5	38 – 82	Jul 29	4
2014	11	1	65	19 – 79	Jul 27	0
2015	35	2	65	14 – 91	Jul 9	10
2016	17	4	66	4 – 84	Jul 28	4
2017	34	5	59	6 – 82	Jul 24	8
2018	65	6	61	5 – 89	Jun 23	16
2019	3	1	68	59 – 68	Sep 7	0
AVERAGE	55	4	57	n/a	n/a	6
TOTAL	**1,047**	**82**	n/a	n/a	n/a	**102**

Possible solutions for WNV problem

Research needs:

- Models must include evidence surrounding vector-host interaction, host immunity, pathogen evolution, land use, social determinants of human health
- Coordinated, systematically collected long-term surveillance data
- Mechanistic models that include data that is specific to vector species and pathogen

CDC Disease Maps



National & state maps (including county-level data) from 2003 – present.

Prevent mosquito bites:

- DEET, permethrin-treated clothes and gear, long pants & sleeves
- Check for water-holding containers
- Screens on windows, bed nets

3 main points to take away

1. Climate change will affect transmission of infectious diseases **directly** (e.g. change in vector population abundance) and **indirectly** (e.g. changes in human migration due to economic effects)
2. **Ticks** capable of carrying the bacteria that cause Lyme disease and other pathogens will show **earlier seasonal activity and a generally northward expansion** in response to increasing temperatures associated with climate change
3. **Rising temperatures, changing precipitation patterns, and a higher frequency of some extreme weather** events associated with climate change will influence the **distribution, abundance, and prevalence of infection in the mosquitoes** that transmit West Nile virus by altering habitat availability and mosquito and viral reproduction rates

Thank you