



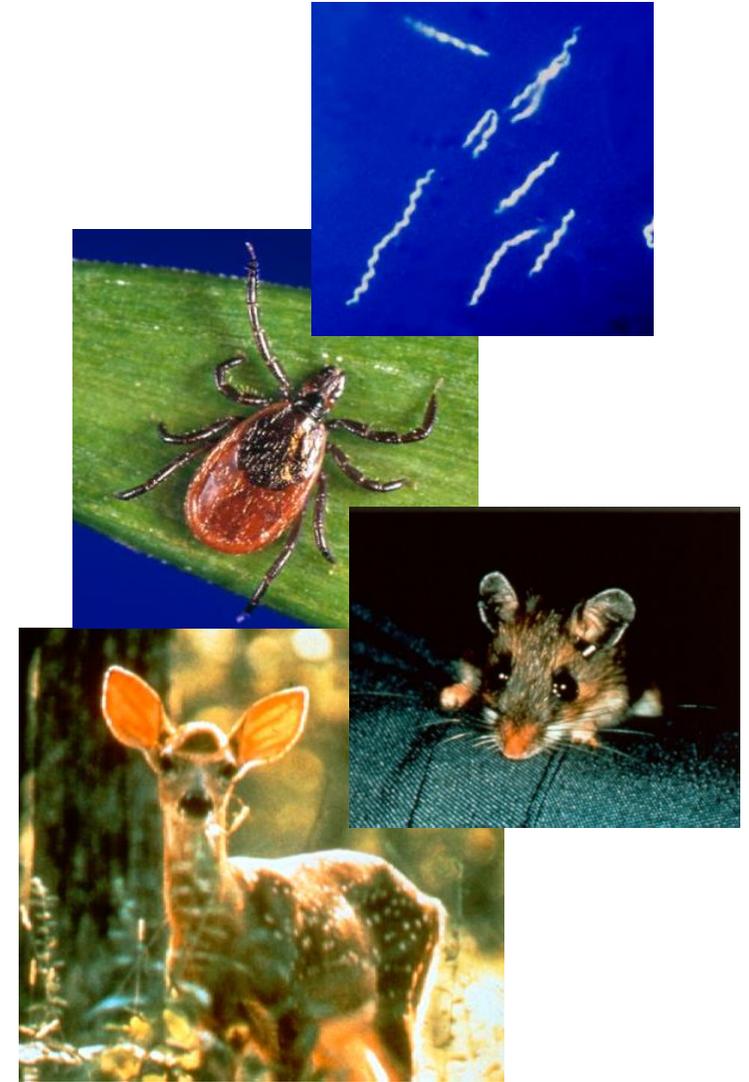
Tick-Borne Disease Burden and Trends in the U.S.

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Outline

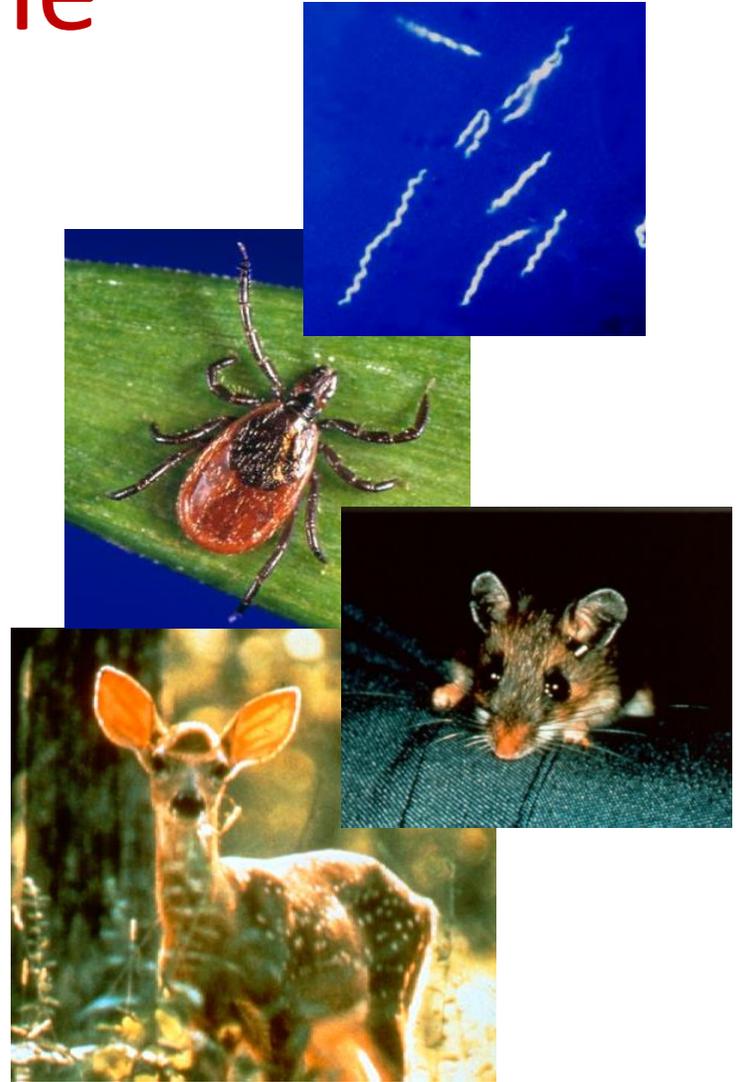
- Key tick-borne diseases, their distributions and vectors
- Current disease burden
- Disease trends and drivers
- Tick-borne disease prevention (briefly)



Key tick-borne diseases, their distributions and vectors

Nationally notifiable tick-borne diseases in the U.S.

- Anaplasmosis
- Babesiosis
- Ehrlichiosis
- Lyme disease
- Powassan virus disease
- Spotted fever rickettsiosis
- Tularemia



Important tick species in the U.S.



Blacklegged Tick



Brown Dog Tick



Rocky Mountain Wood Tick



Lone Star Tick



Groundhog Tick

Steve Jacobs
PSU Entomology



Soft Tick



American Dog Tick



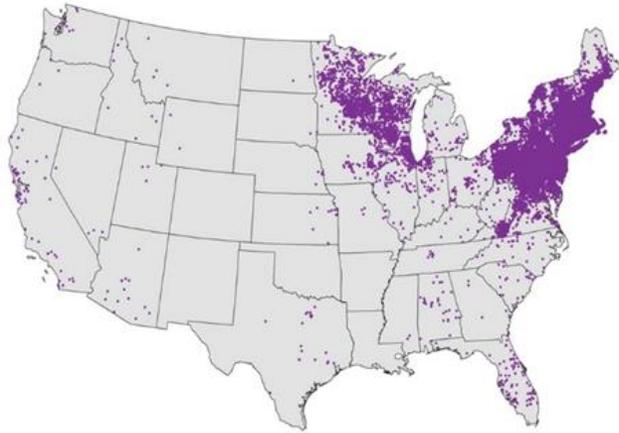
Gulf Coast Tick



Western Blacklegged Tick

Distribution of nationally notifiable tick-borne diseases

Lyme disease



Anaplasmosis



Babesiosis



Rocky Mountain spotted fever



Ehrlichiosis



Tularemia



Current disease burden

Reported cases of tick-borne diseases in the U.S. states and territories, 2016

Diseases	2016 Cases
Anaplasmosis/Ehrlichiosis*	5,750
Babesiosis	1,910
Lyme disease	36,429
Powassan virus disease	22
Spotted fever rickettsioses**	4,269
Tularemia	230
Total	48,610

*All anaplasmosis and ehrlichiosis species, including undetermined

**Includes *R. rickettsii*, *R. parkeri*, *Rickettsia* species 364D

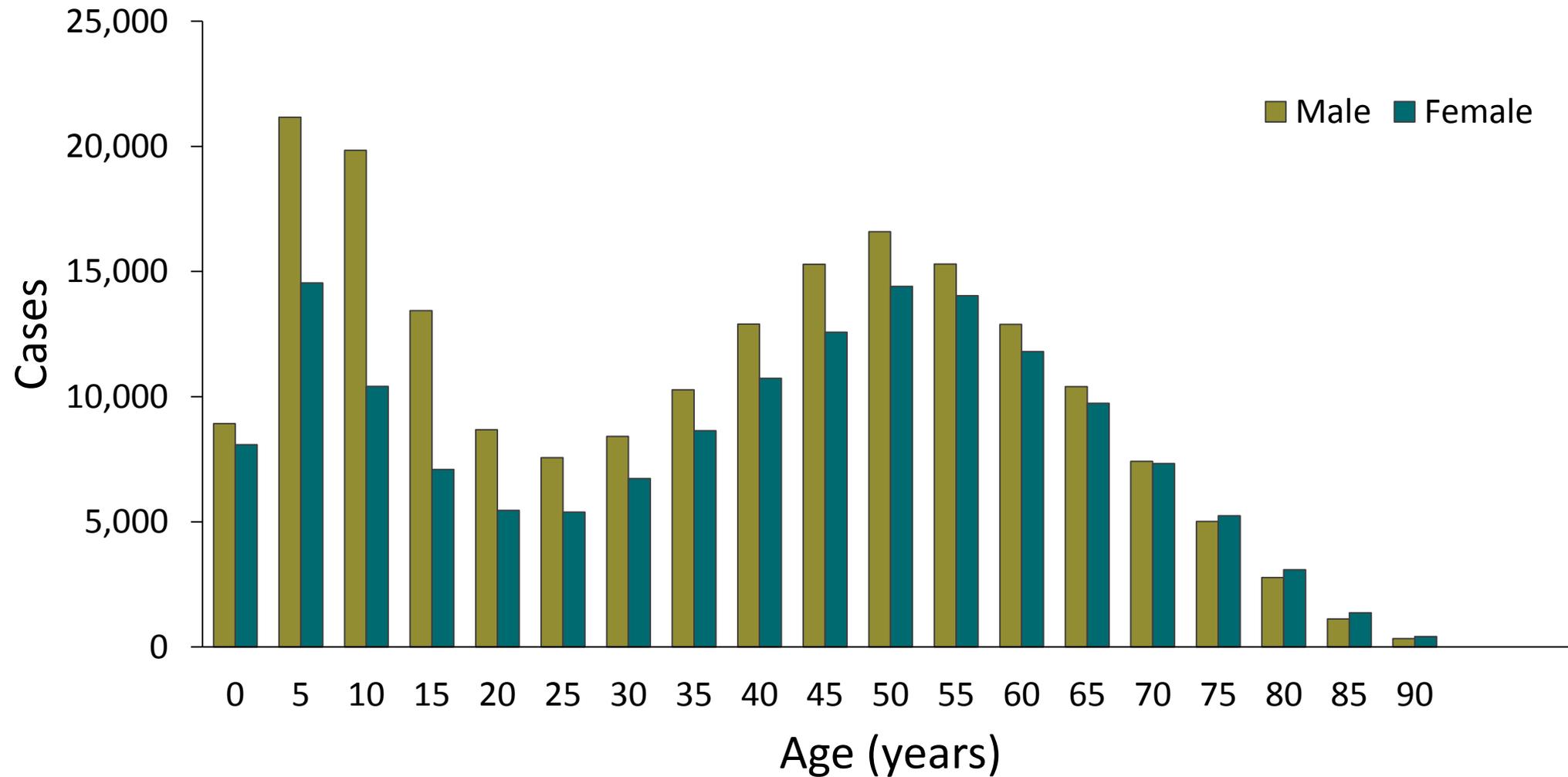
Top notifiable diseases, U.S., 2016

Disease	Cases
Chlamydia	1,598,354
Gonorrhea	468,514
Syphilis	88,042
Campylobacteriosis	60,120
Salmonellosis	53,850
Lyme disease	36,429
HIV diagnoses	34,755
Pertussis	17,972

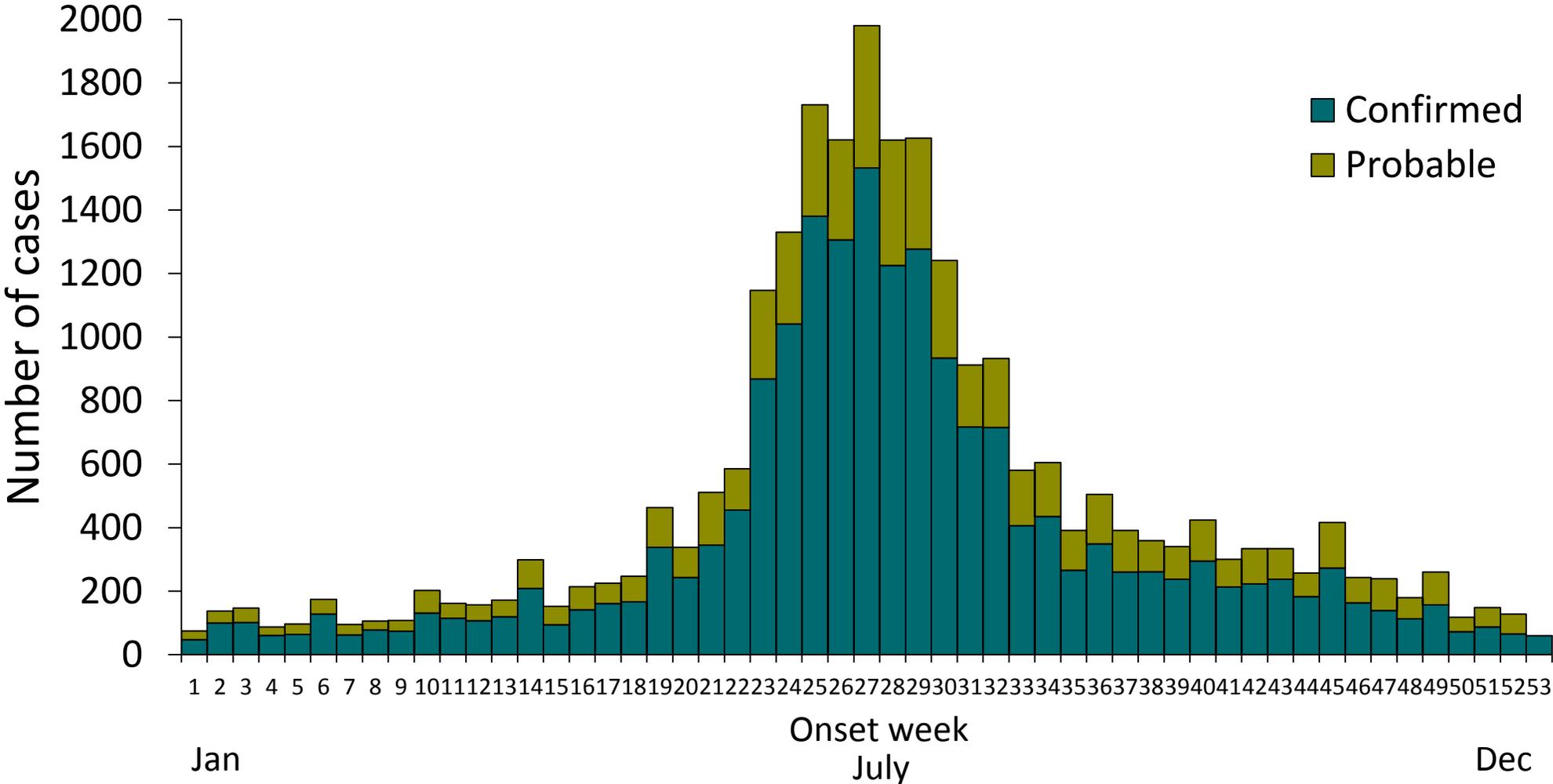
Top notifiable diseases, Middle Atlantic U.S., 2016

Disease	Cases
Chlamydia	200,882
Gonorrhea	51,765
Lyme disease	19,675
Syphilis	13,113
Campylobacteriosis	7,820
Salmonellosis	4,993
HIV diagnoses	4,488
Pertussis	3,124

Confirmed Lyme disease cases by age and sex, U.S., 2001-2016



Reported Lyme Disease Cases by Week of Onset, U.S., 2008 – 2015



Lyme disease under-reporting in the U.S.

- All reportable conditions are subject to under-reporting.
- Magnitude of under-reporting less for diseases that:
 - Are rare or unusual
 - Require hospitalization
 - Have a definitive diagnostic test
- Principal reasons for under-reporting of Lyme disease:
 - Busy health care providers don't fill out the report form.
 - Health departments do not have time to follow up on missing information.

Estimates of Lyme disease under-reporting



State	Year	Under-reporting	Method
CT	1992	6-9 X	MD survey ¹
MD	1992-3	10-12 X	MD survey ²
NY	1991-4	4 X	Tick bite model ³
WI	1992-8	3 X	Record review ⁴

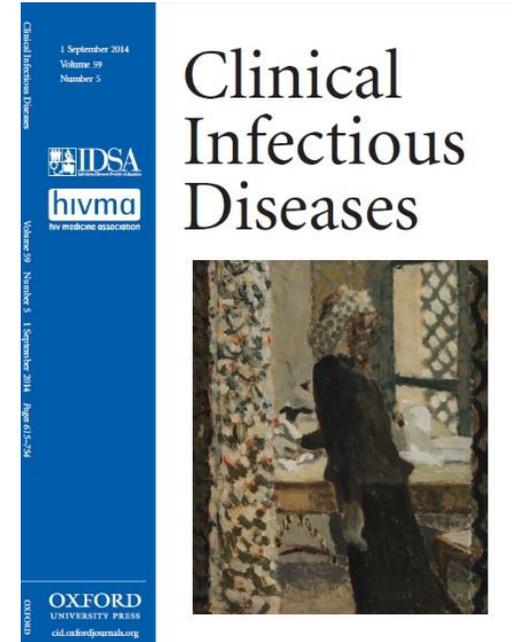
Refs: 1) Meek 1996 2) Coyle 1996 3) Campbell 1998 4) Nalaway 2002

Lyme disease testing by large commercial laboratories in the U.S.

Hinckley A, Connally N, Meek J, *et al.*
Clinical Infectious Diseases 2014; 59:676-81

Results:

- 3.4 million Lyme disease tests conducted annually on 2.4 million patients
- 288,000 estimated infections (Range: 244,000 – 444,000)
- Annual cost of testing alone estimated to exceed \$490M per year

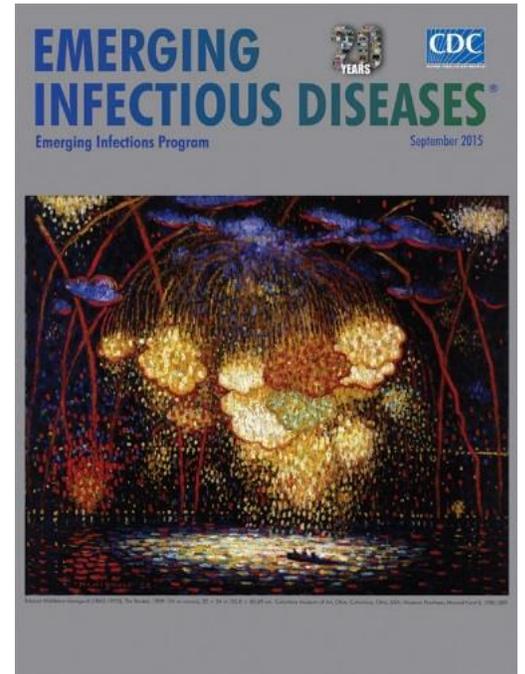


Incidence of clinician diagnosed Lyme disease in the U.S., 2005-2010

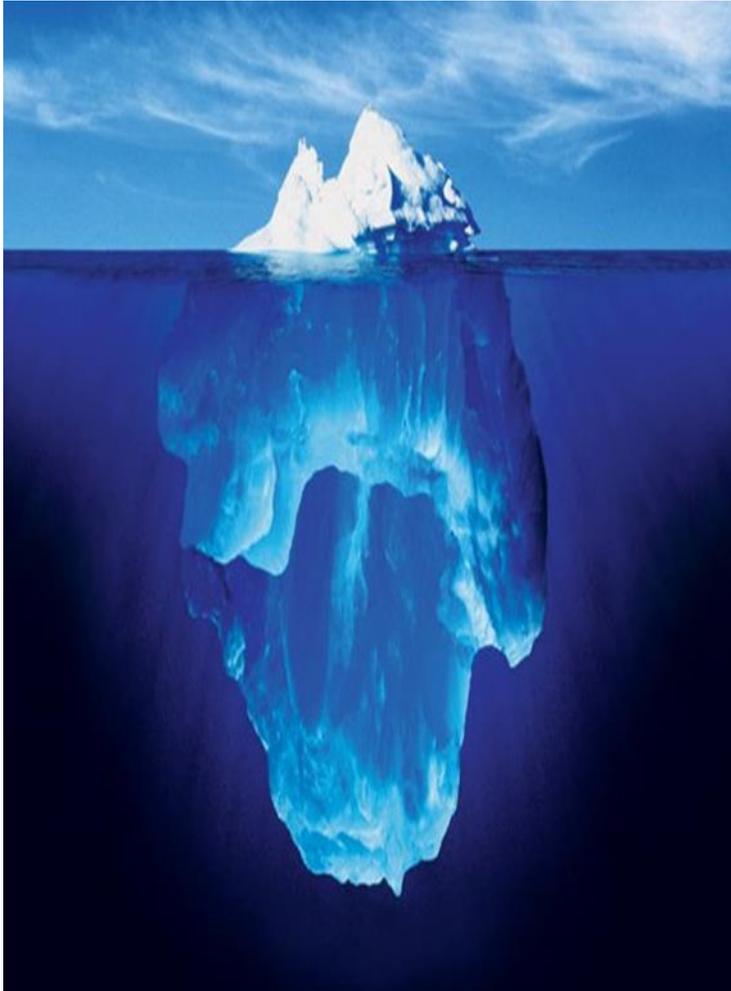
Nelson C, Saha S, Kugeler K, *et al.*
Emerging Infectious Diseases 2015; 21:1625-31

Results:

- >103 mil person-years of observation
- 44,445 outpatient and 985 inpatient Lyme disease diagnoses identified
- Epidemiologic patterns similar to U.S. surveillance data
- Estimated 329,000 patients treated for Lyme disease annually (range 296,000 - 376,000)



Estimates of Lyme disease under-reporting

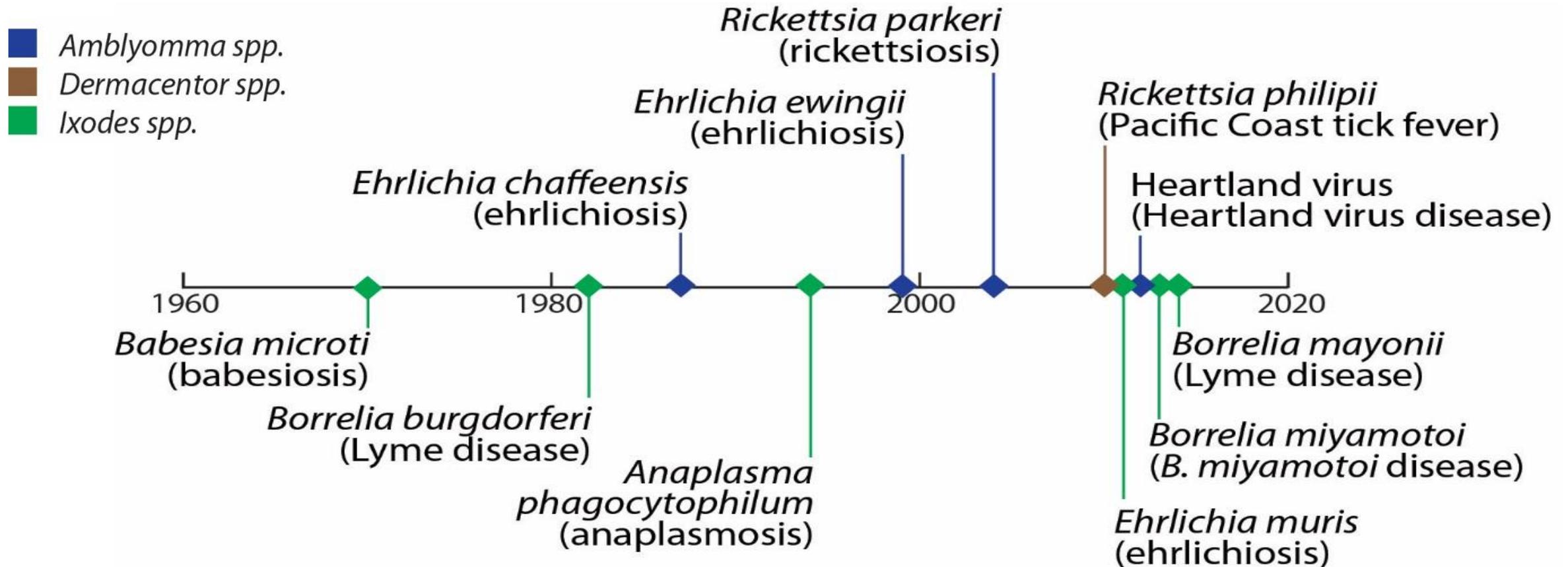


State	Year	Under-reporting	Method
CT	1992	6-9 X	MD survey ¹
MD	1992-3	10-12 X	MD survey ²
NY	1991-4	4 X	Tick bite model ³
WI	1992-8	3 X	Record review ⁴
All	2008,10	8-10 X	Lab survey, ⁵ Claims data ⁶

Refs: 1) Meek 1996 2) Coyle 1996 3) Campbell 1998 4) Nalaway 2002
5) Hinckley 2014 6) Nelson 2015

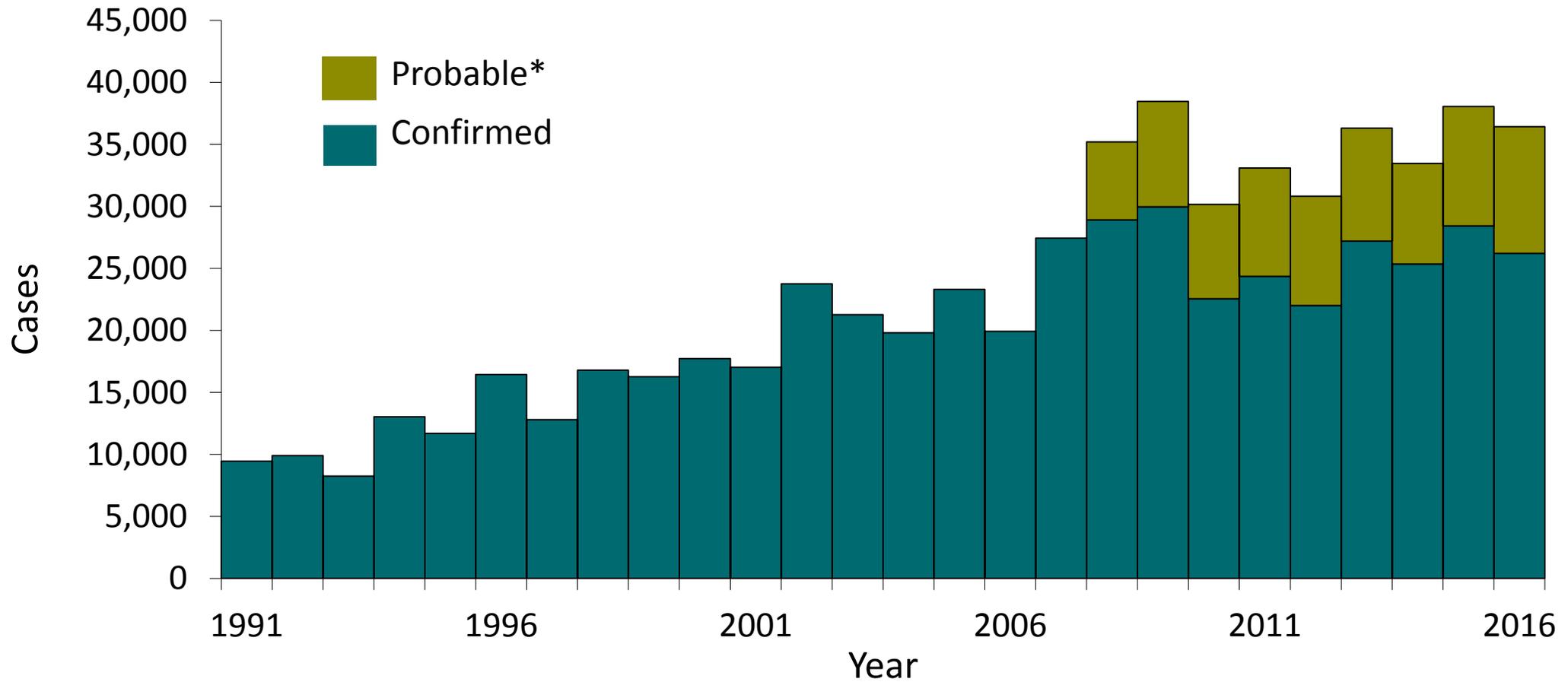
Disease trends and drivers

Discovery of tick-borne pathogens as causes of human disease by year, 1960–2016



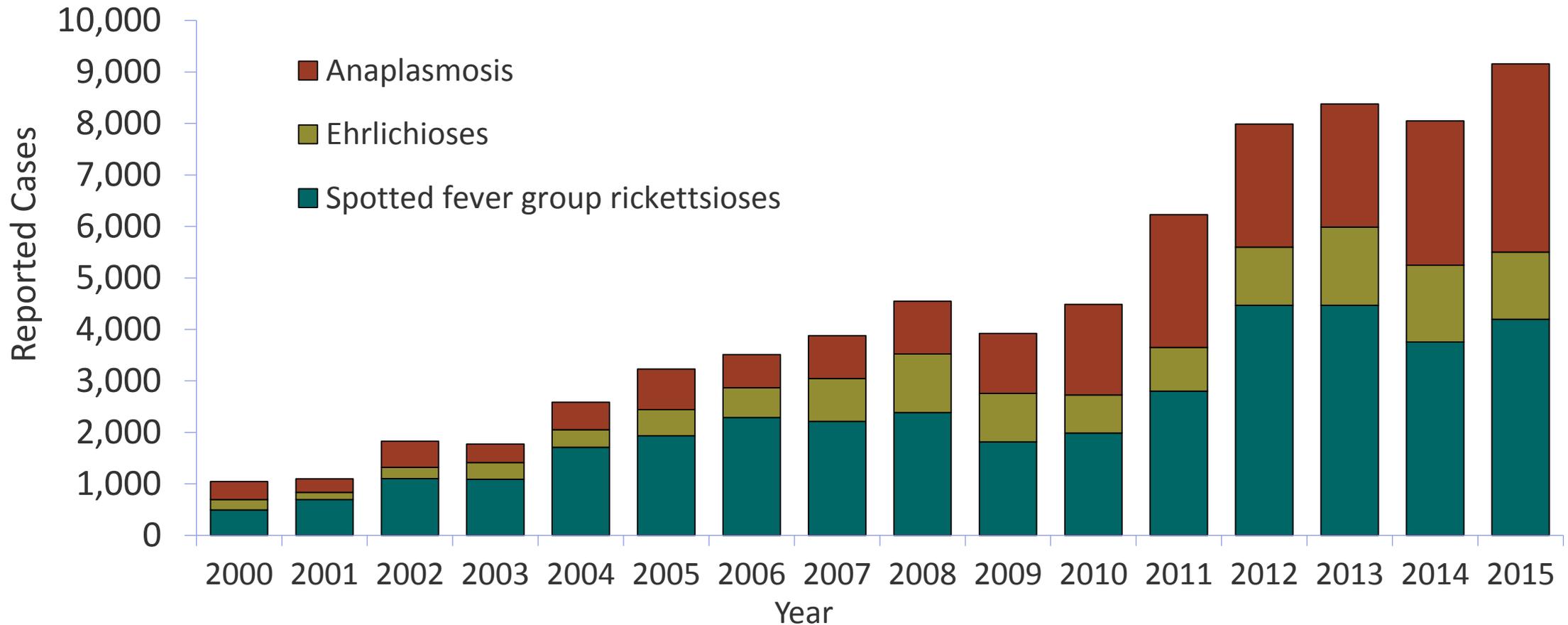
- Year represents when tickborne pathogen was recognized as cause of human disease.
- Adapted from: Paddock CD, Lane RS, Staples JE, Labruna MB. 2016. In: Mack A, Editor. Global health impacts of vector-borne diseases: workshop summary. National Academies Press. p. 221-257.

Reported Lyme Disease Cases by Year, U.S., 1991-2016



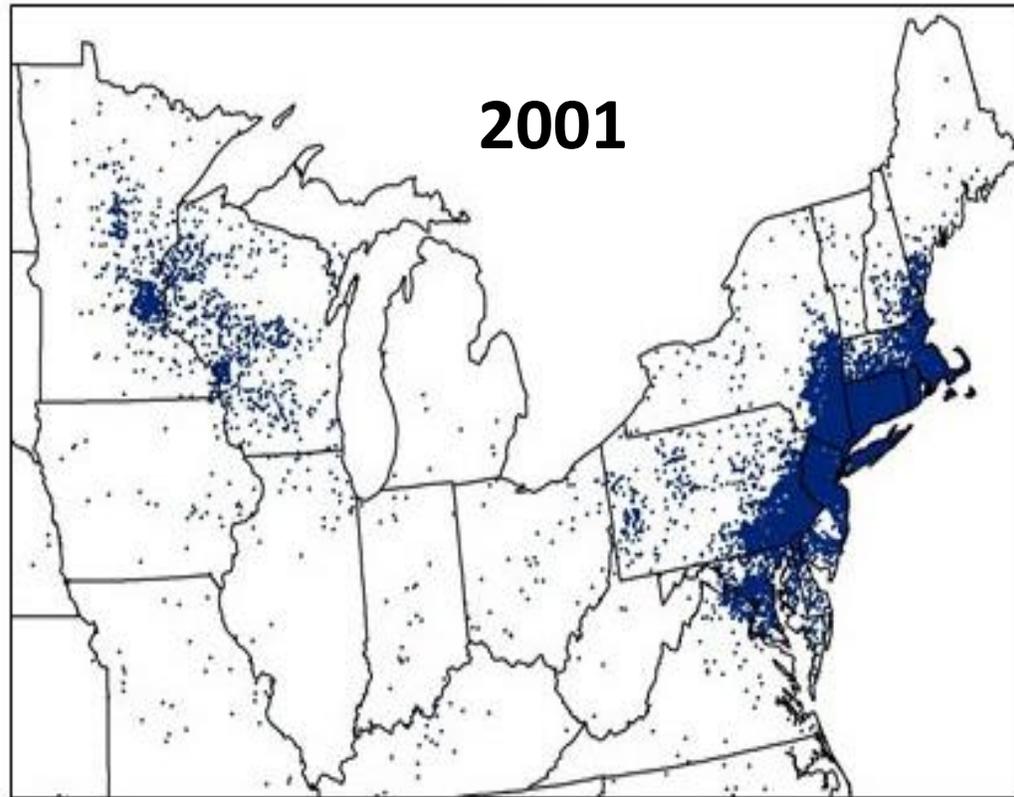
Other nationally notifiable tick-borne diseases have also increased

Annual Reported Cases of Three Selected Tick-borne Diseases, 2000–2015

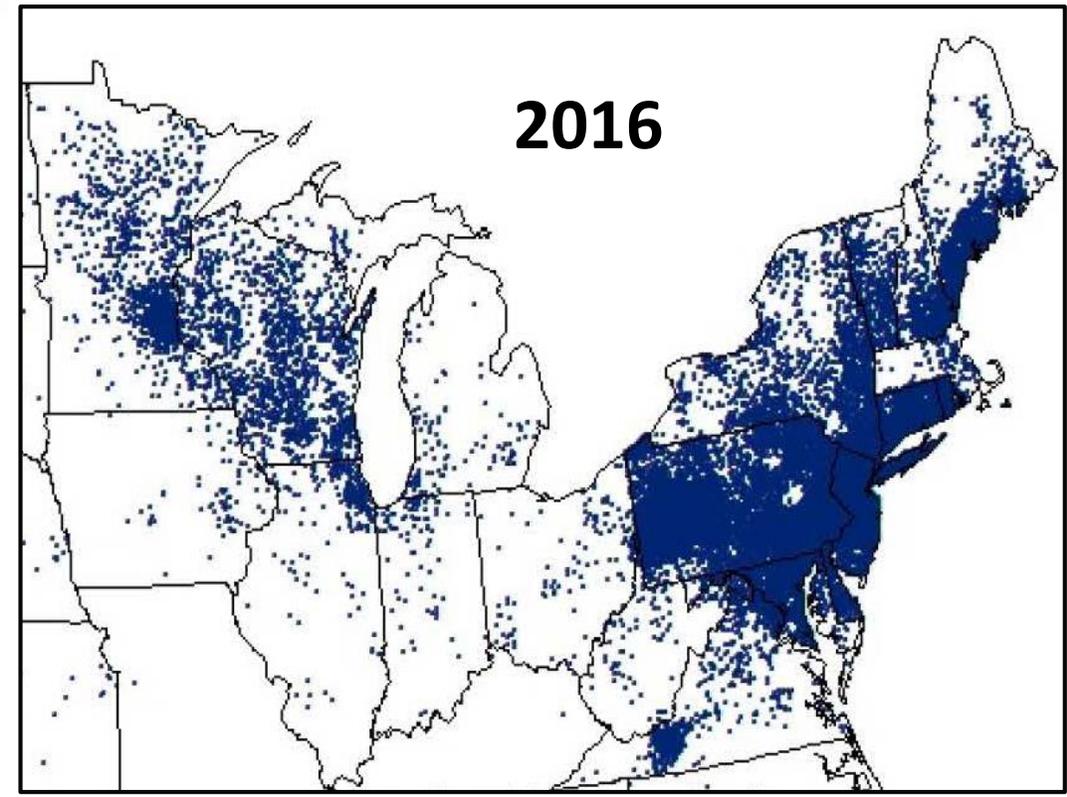


Source: cdc.gov/mmwr/mmwr_nd/index.html ; cdc.gov/mmwr/volumes/65/wr/pdfs/mm6546.pdf

Lyme disease U.S. case distribution: 16-year trend



N = 17,209

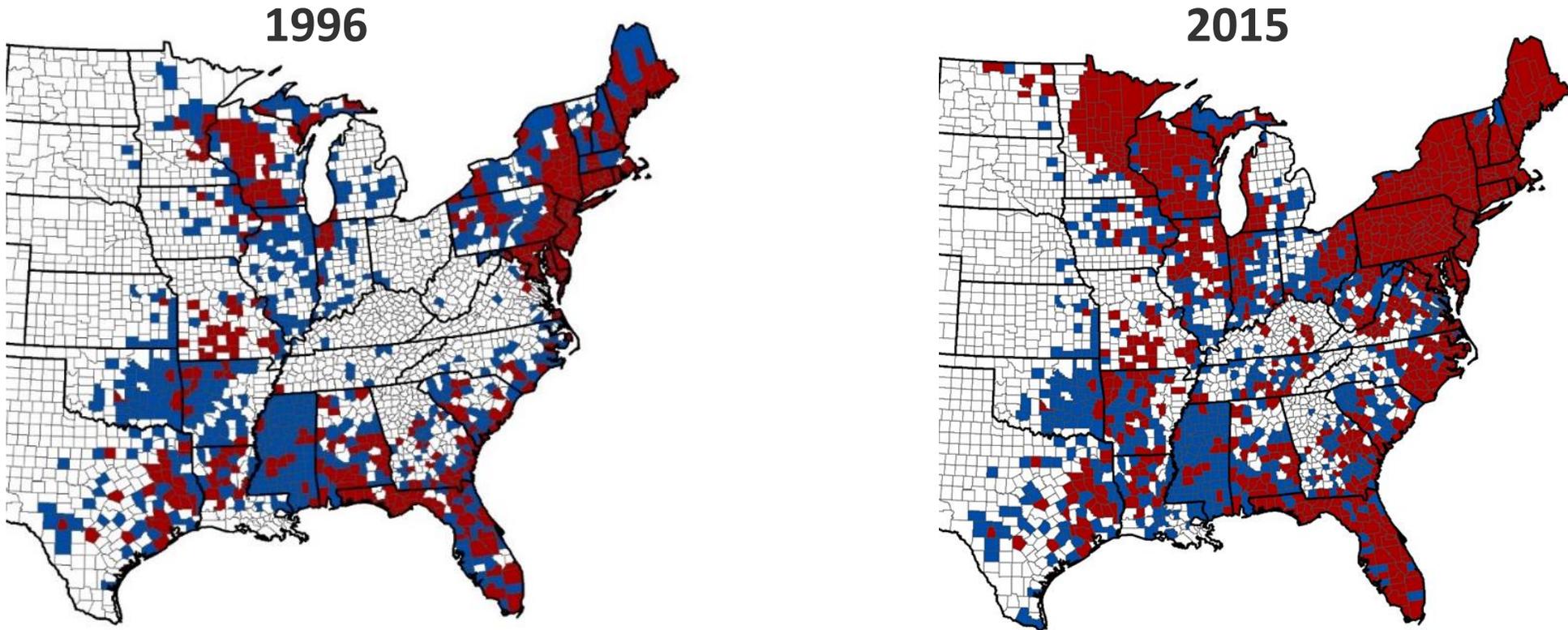


N = 36,429

* One dot placed randomly within county of residence for each confirmed case

Source: <http://www.cdc.gov/lyme/stats/maps/interactiveMaps.html>

Geographic expansion of ticks – locations where *Ixodes scapularis* recorded



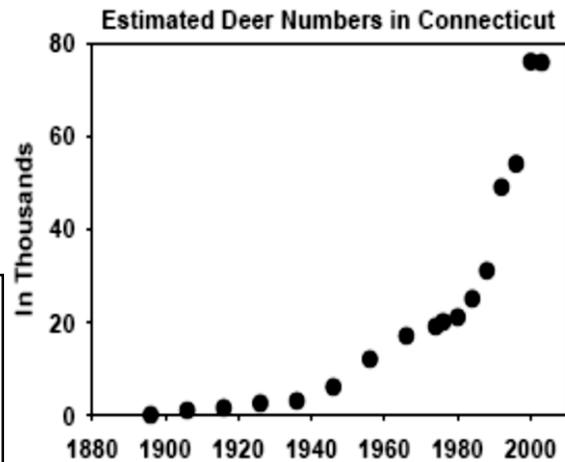
- Established:** ≥ 6 or more ticks or ≥ 1 life stage recorded in a single year
- Reported:** < 6 individuals of a single life stage recorded in a single year

- Dennis DT, Nekomoto TS, Victor JC, et al. J Med Entomol. 1998 Sep;35(5):629-38.
- Eisen RJ, Eisen L, Beard CB. J Med Entomol. 2016 Mar;53(2):349-86.

Tick-borne disease emergence – re-emergence in the U.S.



Source:
Bald hills: New England before the trees returned. From *Thoreau's Country*.
American Scientist Online
<http://www.americanscientist.org>

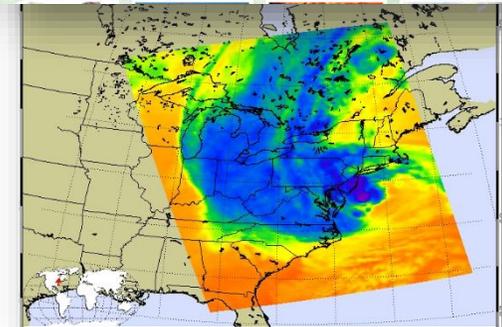
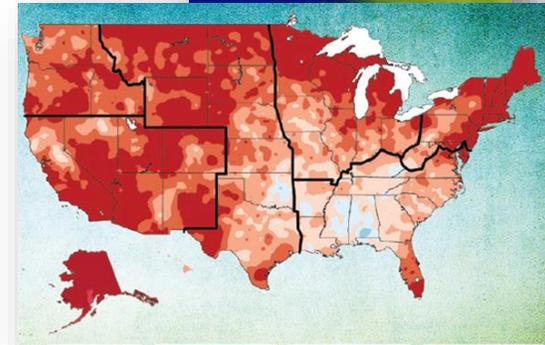


Source: K. Stafford, CT Agricultural Experiment Station

- Reforestation
- Overabundant deer
- Expansion of suburbia into wooded areas
- Abundant habitat around homes for Lyme reservoir hosts
- Increased numbers of ticks
- Increased exposure opportunities in people
- Changing climate

Climate, weather, and tick-borne diseases

- Warmer annual temperatures will result in a generally northward expansion in tick distribution.
- Warmer temperatures increase reproductive capacity of ticks, leading to larger populations of ticks.
- Higher moisture levels allow tick survival in warmer environments.
- With milder winters and earlier springs, tick vectors will likely show earlier seasonal activity.
- Larger tick populations, longer seasonal activity and expanding range of ticks will likely increase risk of human exposure to infected tick.



Brownstein, J. S., T. R. Holford, and D. Fish. 2003. *Environ Health Persp* 111: 1152-1157

Eisen, L., R. J. Eisen, and R. S. Lane. 2002. *Med Vet Entomol* 16: 235-244

Yuval, B., and A. Spielman. 1990. *J Med Entomol* 27: 196-201

Moore, S. M., R. J. Eisen, A. Monaghan, and P. Mead. 2014. *Am J Trop Med Hyg* 90: 486-496

Beard, C.B., Eisen, R.J., Barker, C.M. et al. 2016. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 129–156. <http://dx.doi.org/10.7930/J0765C7V>

Tick-borne disease prevention

Protection against tick-borne diseases

No vaccines are currently available in the U.S., but a Lyme disease vaccine trial is underway in Europe...

Valneva Reports Positive Phase I Interim Results for Its Lyme Vaccine Candidate VLA15

Phase I study (VLA15-101) primary endpoint met

- No safety concerns associated with VLA15 in any treatment group

Encouraging immunogenicity with VLA15

- VLA15 is immunogenic in all doses and formulations tested
- Good OspA-specific IgG antibody responses against all OspA serotypes

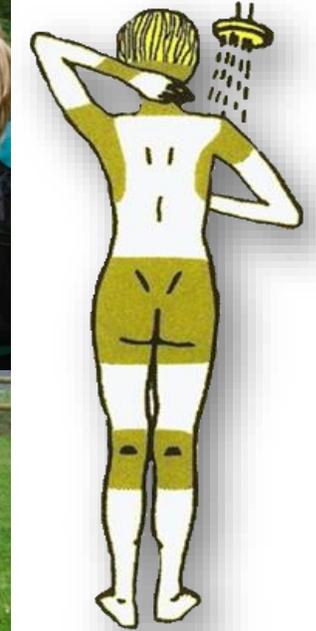


VALNEVA SE
World Trade Center Lyon
Tour Oxygène
10-12 boulevard Marius Vivier Merle
69007 Lyon, France

Source: <http://www.valneva.com/en/investors-media/news>

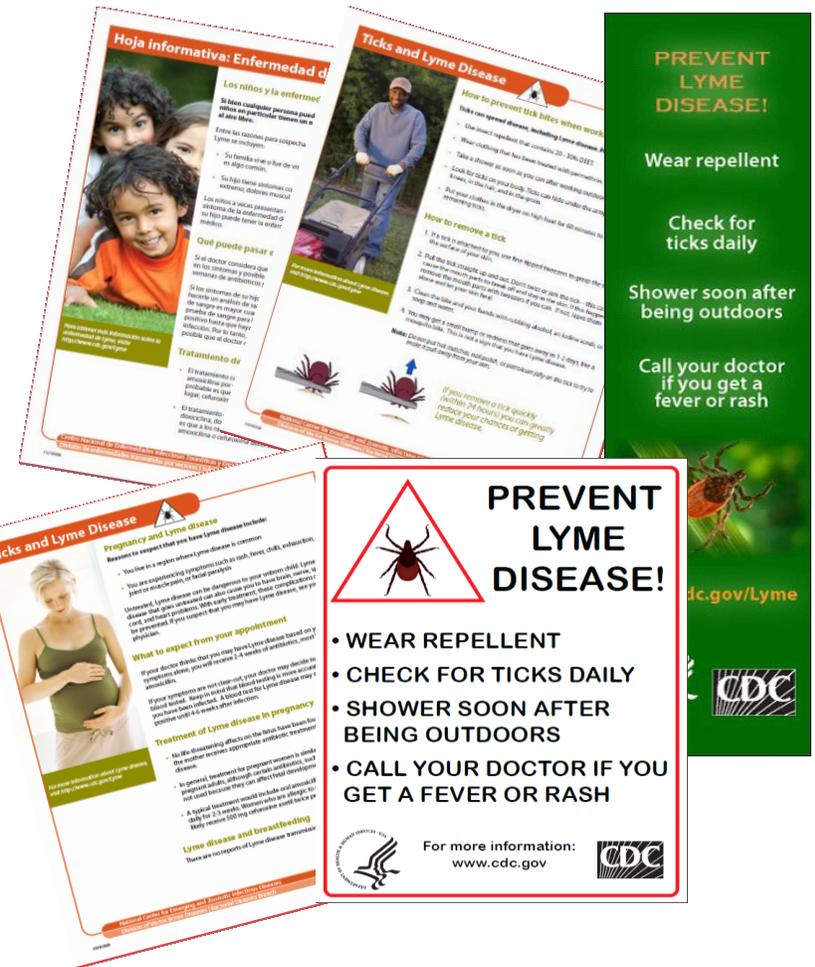
Protection against tick-borne diseases relies on ...

- Reducing exposure to ticks
 - On persons, pets, and property
- Quickly removing any ticks on people or their clothing
- Early and accurate diagnosis and treatment



Lyme disease prevention toolkit

- Brochure
 - Lyme Disease: A Public Information Guide
- Fact Sheets
 - Lyme disease prevention fact sheet for outdoor workers
 - Lyme disease prevention fact sheet for hikers
 - Lyme disease prevention fact sheet for golfers
 - Lyme disease fact sheet for pregnant women
 - Lyme disease fact sheet for parents
- Radio PSAs
 - Lyme disease prevention (3 versions)
 - Talking to Patients about Preventing Tick Bites
- Trail Sign
- Lyme Disease Prevention for Kids
 - Crossword puzzle and information sheet for kids
 - Prevention bookmarks



<http://www.cdc.gov/lyme/>

Summary and Conclusions

- Tick-borne diseases are an important public health concern in the U.S.
- Tick-borne diseases are increasing in the U.S. in incidence, distribution, and in the numbers of new disease agents.
- The drivers for tick-borne disease emergence are related to increasing exposure to infected ticks, largely a result of increasing deer populations and other changes in natural or built environments.
- In the absence of vaccines to any tick-borne disease in the U.S., primary prevention focuses on reducing exposure to ticks and quickly removing any ticks on people or their clothing.

Thank you for your time and interest!



Acknowledgments:
Numerous staff in CDC's
Division of Vector-Borne
Diseases but particularly Paul
Mead, Gil Kersh, Becky Eisen,
Susanna Partridge and Ann
Perea

The findings and conclusion in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.