# Climate Change, Ecology, and Disease Emergence – A Public Health Perspective

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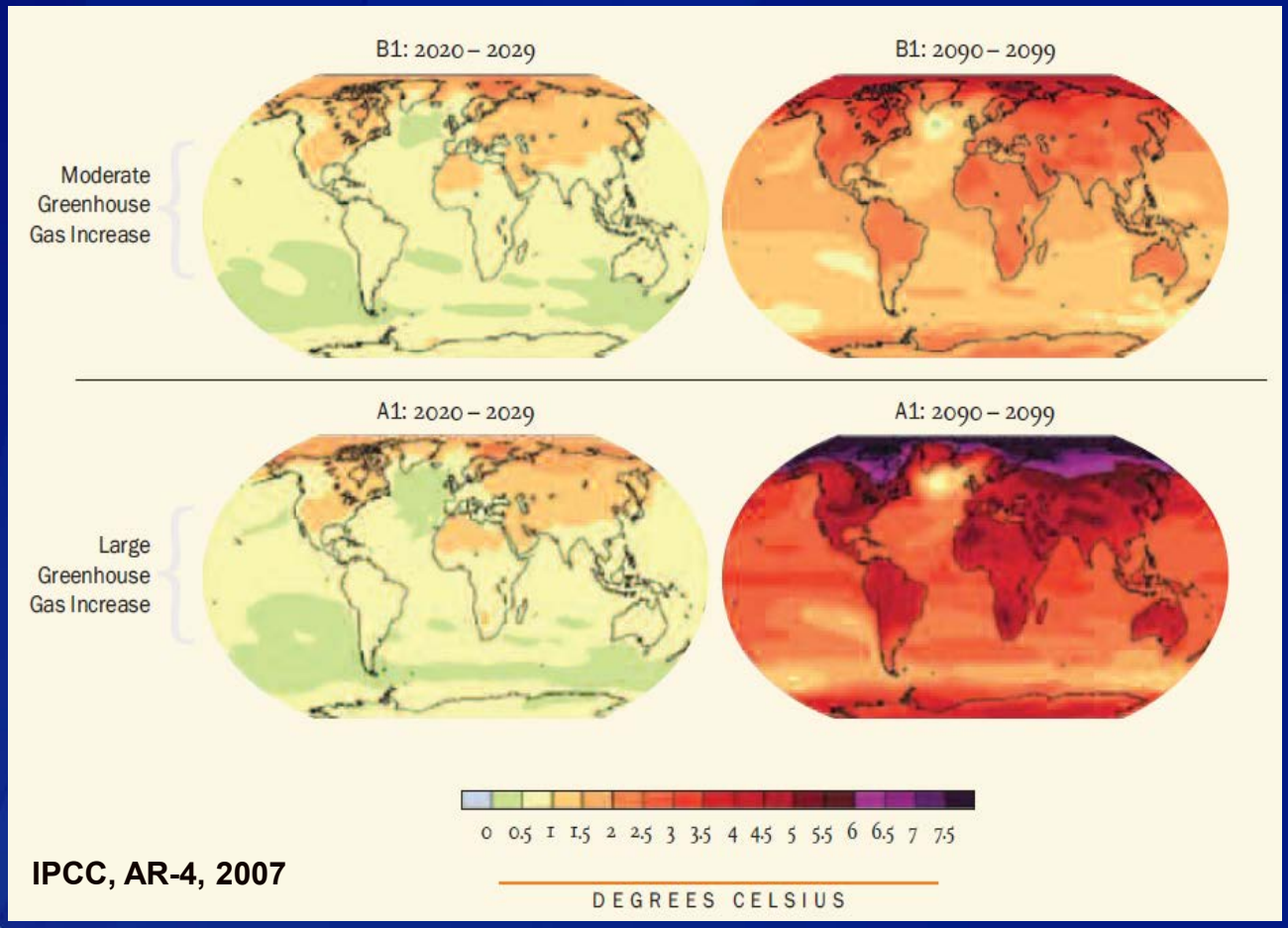
# Outline

- Climate change projections and observations
- Climate-sensitive infectious diseases – incidence and trends
- Climate change, *One Health*, and disease emergence – a case study
- Developing a public health framework

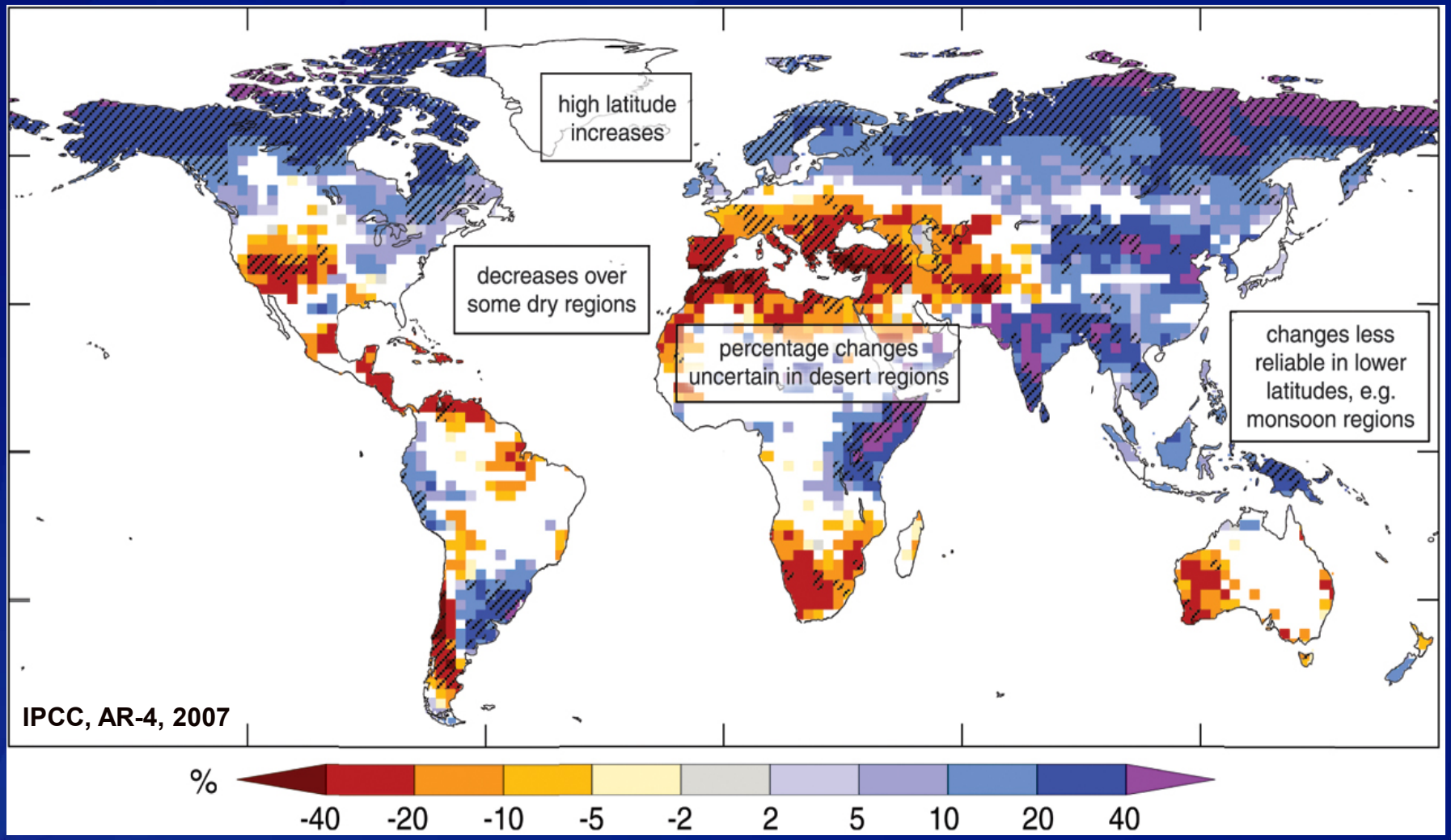
# Changes in Global Temperatures




IPCC, AR-4, 2007

By 2100, global mean temperatures are expected to increase by 2° to 11.5°F according to different models.

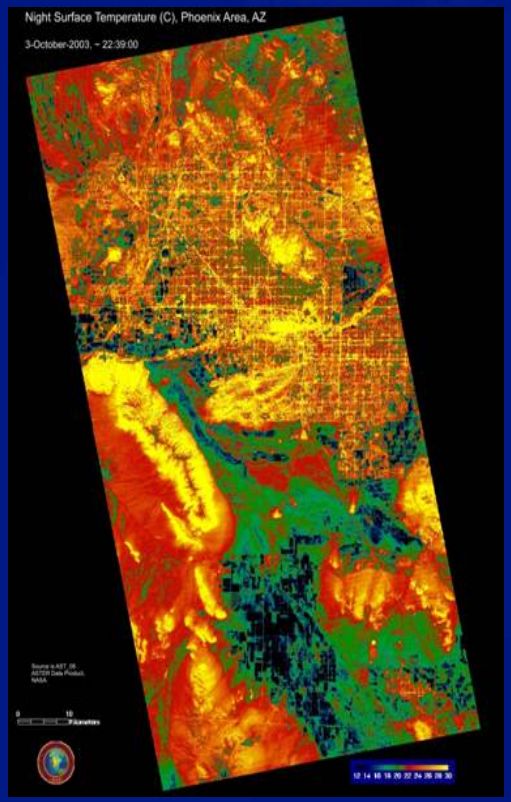
# Changes in Precipitation



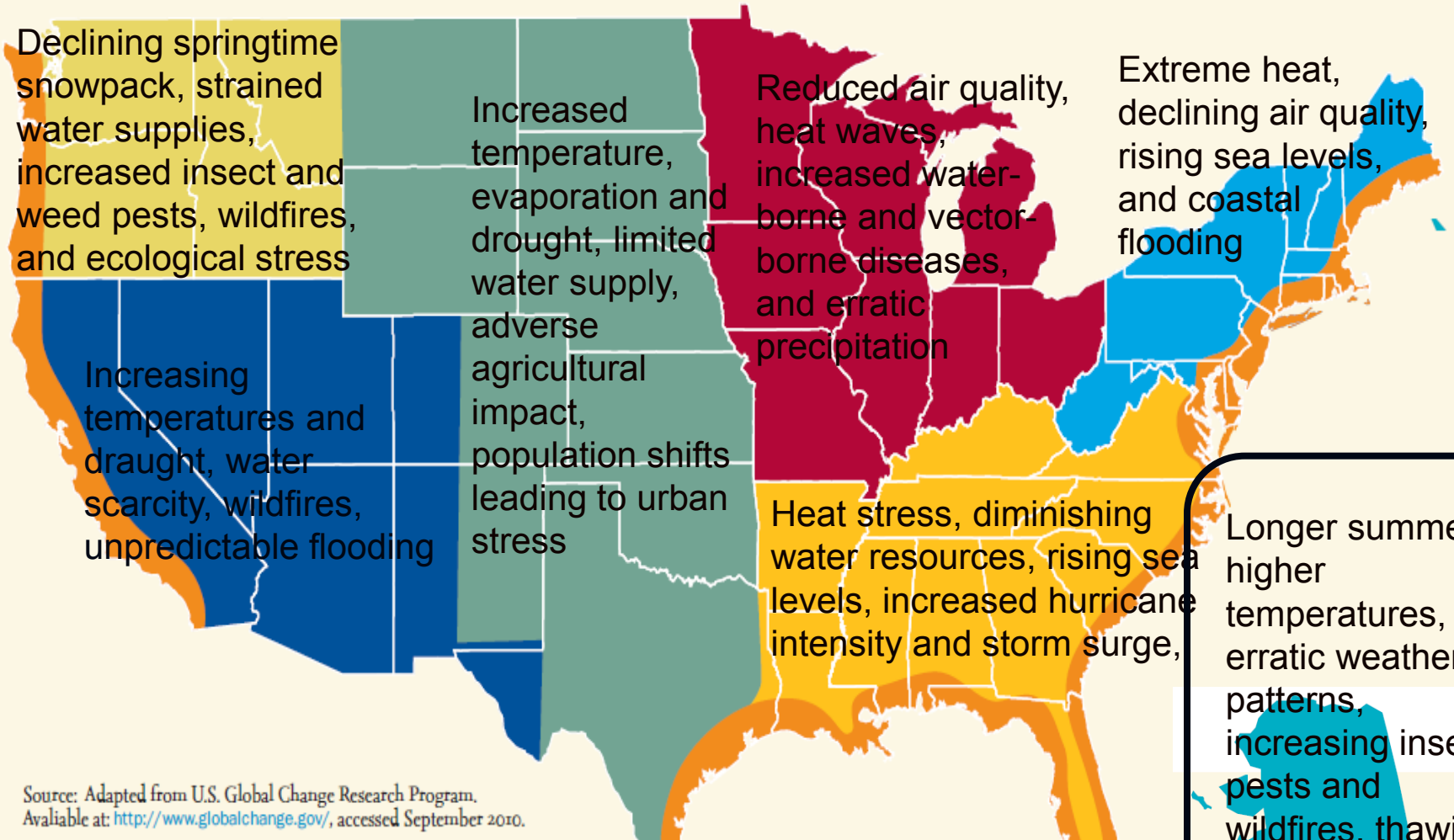
# Climate Change = Climate Variability and Disruption

Some anticipated trends…

- Longer and warmer summers
- Shorter and milder winters
- Increased frequency of severe and unpredictable weather events (e.g. storms, heat waves, draughts)
- Regional variations



# Regional Differences Due to Climate Change



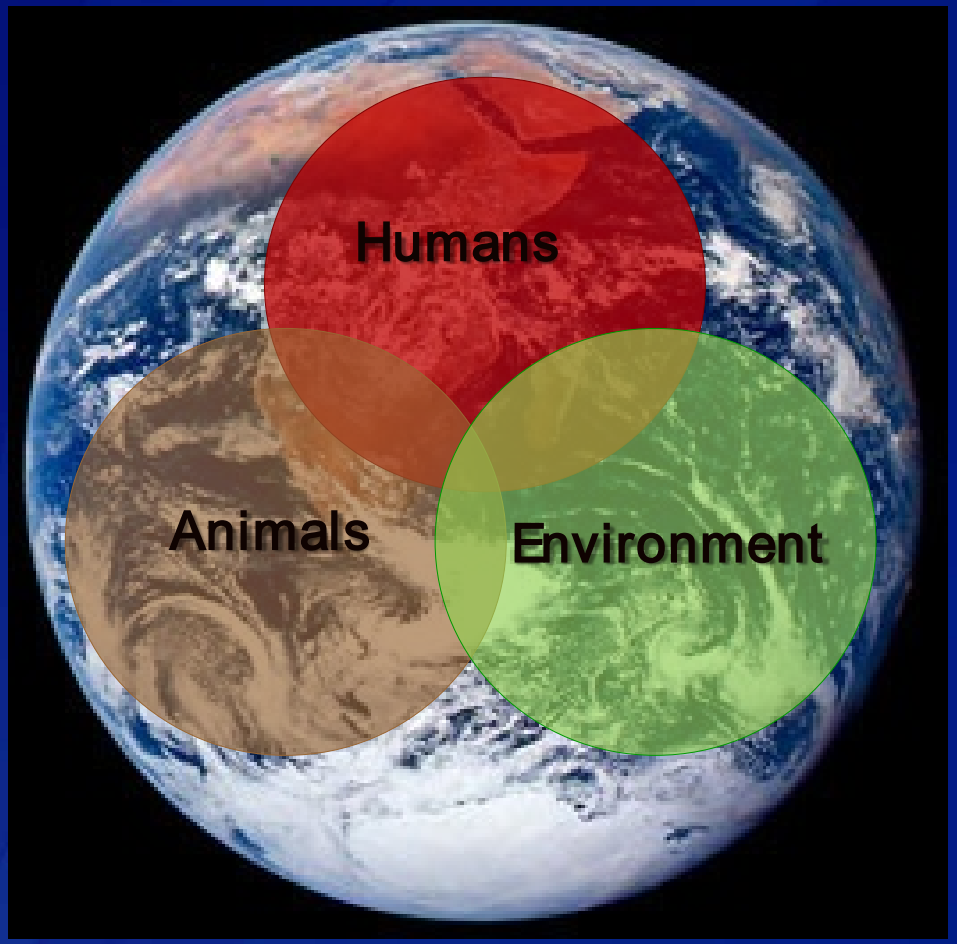

Source: Adapted from U.S. Global Change Research Program. Avaliable at: http://www.globalchange.gov/, accessed September 2010.

**Reference: APHA & CDC, Climate Change: Mastering the Public Health Role, April 2011**

# Climate Change Impact

- Glacier recession and thawing permafrost
- Food security issues
  - Food availability
  - Food spoilage
- Sea ice loss and coastal erosion
- Relocation of Alaskan native tribal villages
- Significant changes in subsistence livelihood

# One World – One Health



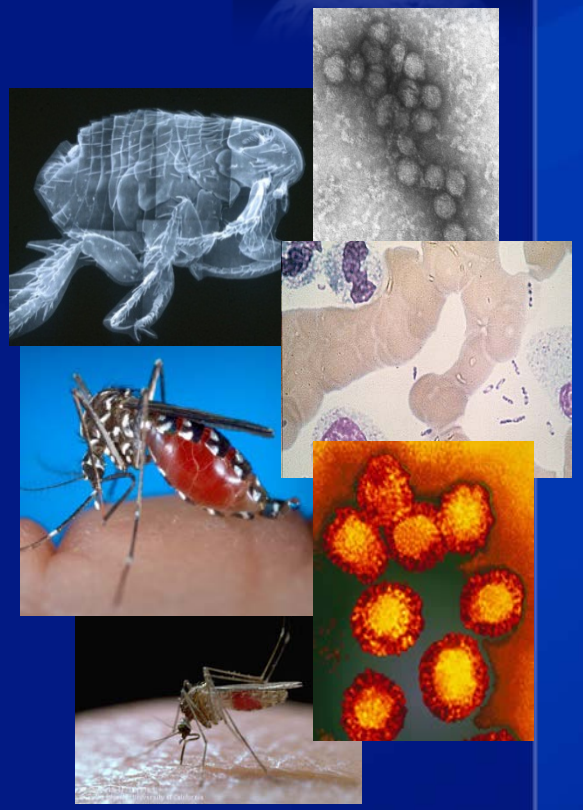

Changes in climate lead to changes in the environment, which lead to changes in ecology, which result in changes in the incidence and distribution of diseases

# Climate, Weather, and Infectious Diseases

- Climate affects the distribution and abundance of vectors (e.g. ticks, mosquitoes), hosts, and pathogens
- Climatic variables (temperature and rainfall) affect disease transmission efficiency by impacting vector-pathogen physiology, interaction, and survival
- Climatic perturbations (ex. severe storms, draughts, weather patterns, ENSO, etc.) affect disease occurrence patterns and drive disease outbreaks
- Changes in climate will result in changes in incidence and distribution of environmentally-associated diseases

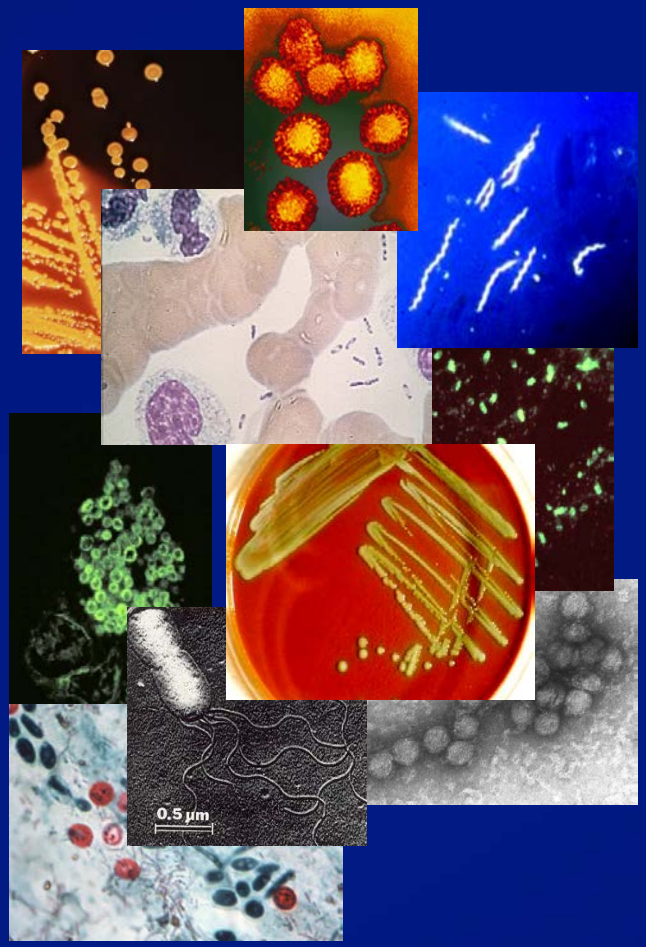
# Climate-Sensitive Infectious Diseases…

- Vector-borne
- Zoonotic
- Waterborne
- Other environmentally sensitive, primarily foodborne and dust-associated



# Infectious Diseases and Agents Potentially Affected by Climate Change*

- Vector-borne & Zoonotic
  - West Nile virus
  - Lyme disease
  - Plague
  - Rabies
  - Dengue
  - Malaria
  - VHFs and Orthopoxviruses
- Environmentally-associated
  - *E coli* O157H7
  - *Burkholderia pseudomallei* (Meilioidosis)
  - *Leptospira*
  - Vibriosis
  - *Cryptococcus gattii*
  - *Coccidioides immitis* (Valley Fever)
  - Naegleria fowleri (PAM)



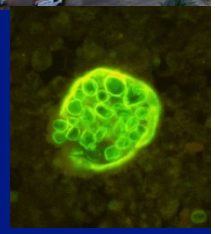

** Incomplete listing of representative diseases/agents*

# Environmentally-sensitive Diseases in the U.S. – Recent Observations*

- Inter-annual trends in West Nile virus epizootics and epidemics
- Changes in the incidence and distribution Lyme and other TBDs
- Autochthonous dengue transmission in southern Florida
- Northward expansion of Eastern Equine Encephalitis
- Valley Fever (coccidioidomycosis) emergence in the western U.S.
- *Cryptococcus gattii* emergence in the Pacific NW

** Not necessarily linked to climate change*



You are here: Home » Climate Change » Is Global Warming Causing the West Nile Virus Outbreak?

# Is Global Warming Causing the West Nile Virus Outbreak?

Editor Post | August 30, 2012 | 1 Comment

Tweet 11 Share Like 12 Pin it Print

**In The American West, The Hottest Year On Record Forces Us To See Things As They Are**

# It's official: This is the hottest summer ever in Denver

Posted on: 9:11 pm, August 27, 2012, by Hema Mullur, *updated on: 09:12pm, August 27, 2012*

Recommend 69 69 Pinterest 0 Share 84 Twitter 15 Email

DENVER — Monday sealed the deal. Denver has officially experienced the hottest summer ever on record.

The high at Denver International Airport reached 98 degrees. It set a record for the high temperature for August 27, and it was the 62nd day we've had that hit 90 degrees or above. The old record was 61 in 2000.

September 5, 2012
THE HUFFINGTON POST
THE INTERNET NEWSPAPER: NEWS BLOGS VIDEO COMMUNITY



# Hottest Year Ever

Page: 1

## The Hottest Year On Record For Northeast So Far

AP | Posted 08.07.2012

**Read More:** Warmest Year on Record, Video, Hottest Year on Record, Hottest Year Ever, Hottest Year Ever Northeast, Warmest Year Ever, Ap, Hottest Northeast, Green News

ITHACA, N.Y. (AP) – No surprise for Northeast residents sweating out the summer after a winter barely touching their snow shovels: this is the hotte...

Read Whole Story

## Warmest 12 Months On Record For U.S. Mainland

The Huffington Post | Joanna Zelman | Posted 07.09.2012

**Read More:** Climate Change Heat Wave, Warmest Year on Record, Noaa State of the Climate, Noaa Heat, Video, Heat Wave Climate Change, Hottest Year on Record, Noaa Climate Change, Hottest Year Ever, Hottest Year, Warmest Half Year, Noaa, Green News

Yes, it really is getting hot out there. A new report finds that the past 12 months have been the warmest on record for the mainland United States. ...

Read Whole Story

## 2010 Ties 2005 For Hottest Year Ever Recorded

AP | RANDOLPH E. SCHMID | Posted 05.25.2011

**Read More:** Warmest Year on Record, 2010 Temperature, Warmest Year 2010, Hottest Year on Record, Hottest Year on Record Globally, Hottest Year Ever, 2010 Hottest Year on Record, Climate Change, Hottest Year on Record Worldwide, Warmest Year Ever, What Is the Hottest Year on Record, Hottest Year 2010, Green News

"West Nile virus outbreak triggers Dallas, TX state of emergency declaration: city to begin first aerial spraying in 46 years"

August 16, 2012

# West Nile Virus – The Summer of 2012

- Approximately 5,400 human cases
- Cases reported from all lower 48 states
- Largest outbreak since 2003
- Focally-intense outbreak distribution
  - ~ 1/3 of all cases reported from Texas
  - ~ 50% of Texas cases reported from the 4-county area around Dallas

# Climate Variability, Temperature and West Nile Virus Transmission

- General consensus is that the high level of WNV activity in the U.S. in 2012 was likely influenced by…
  - Mild winter
  - Early spring
  - Warm summer
- Subsequent long growing season together with the hot summer resulted in increased mosquito reproductive cycles and accelerated virus replication, thus facilitating a greater risk for WNV amplification and transmission to humans

# Case Study: Lyme Disease in the U.S.

# Lyme Disease

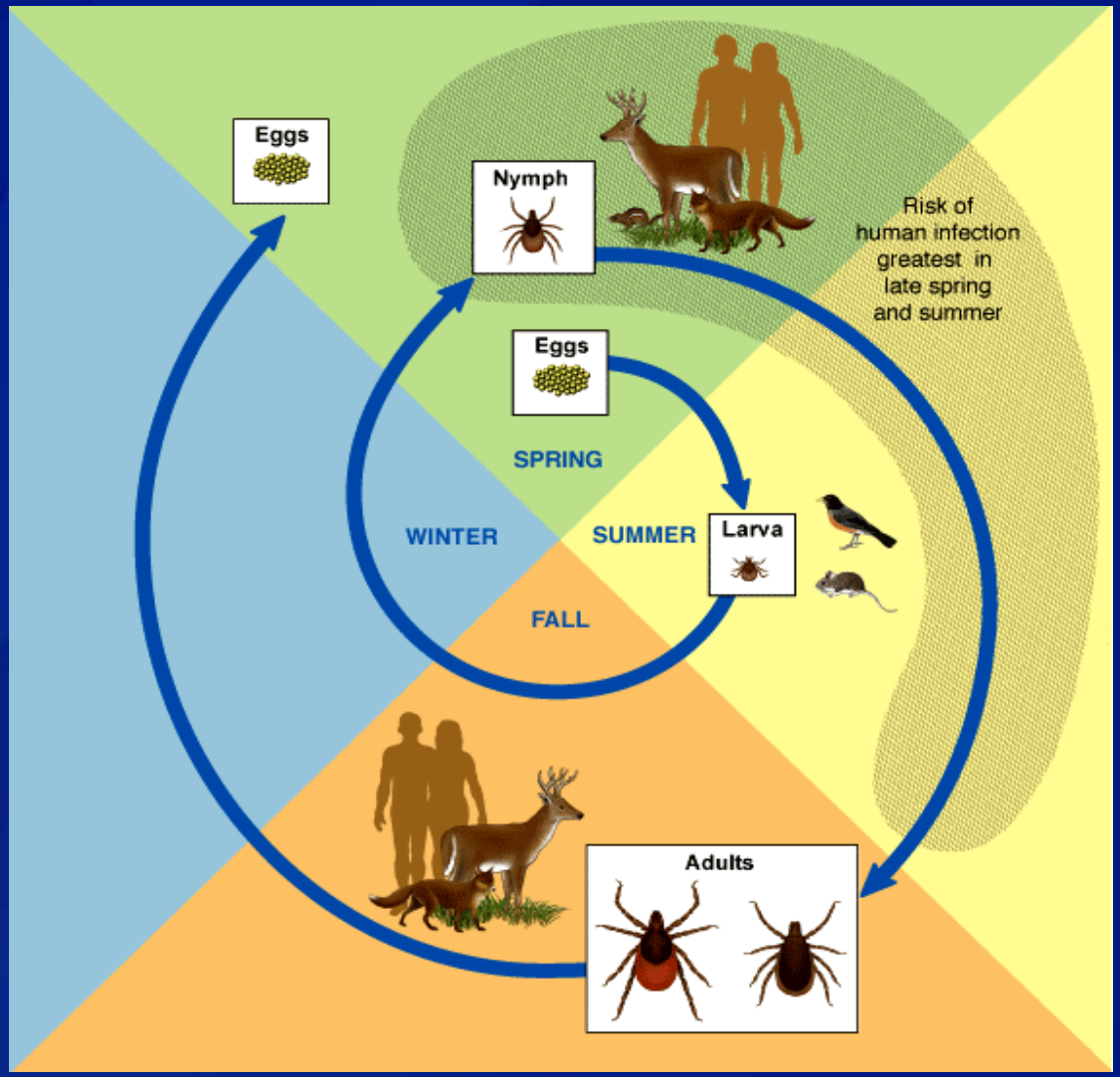
- Caused by the spirochetal bacterium *Borrelia burgdorferi*
- Transmitted by *Ixodes* spp. ticks
- Reservoirs for the spirochete include
  - Small mammals (field mice, squirrels, chipmunks, etc.)
  - Birds
- Hosts for the tick include
  - Small mammals (larvae & nymphs)
  - Deer and other large mammals (adults)
- Deer required for tick population maintenance



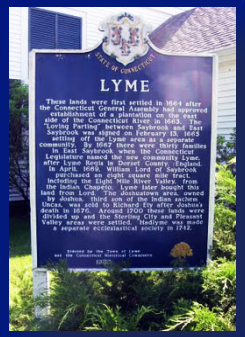

# Lyme Disease

- Typical symptoms include…
  - Fever
  - Headache
  - Fatigue
  - Characteristic skin rash, erythema migrans, seen in approximately 80% of cases
- If left untreated, infection can spread to joints, the heart, and the nervous system
- Most common "vector-borne" disease in the U.S.

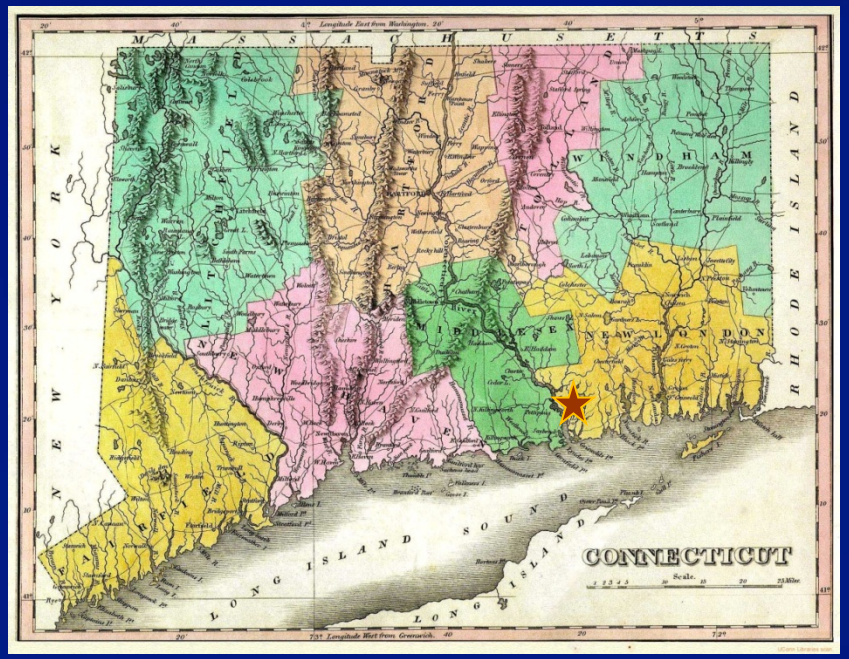
# Lyme Disease Transmission Cycle



# Lyme Disease – History and Emergence




- 1st cases of juvenile rheumatoid arthritis in late 1970's – Lyme, CT
- The agent *Borrelia burgdorferi* was discovered and described in early 1980's
- Earlier reports, 1940's …Montauk Point, Long Island, NY




Source: The *Connecticut Digital Map Library*
http://www.rootsweb.com/~usgenweb/maps/connecticut/

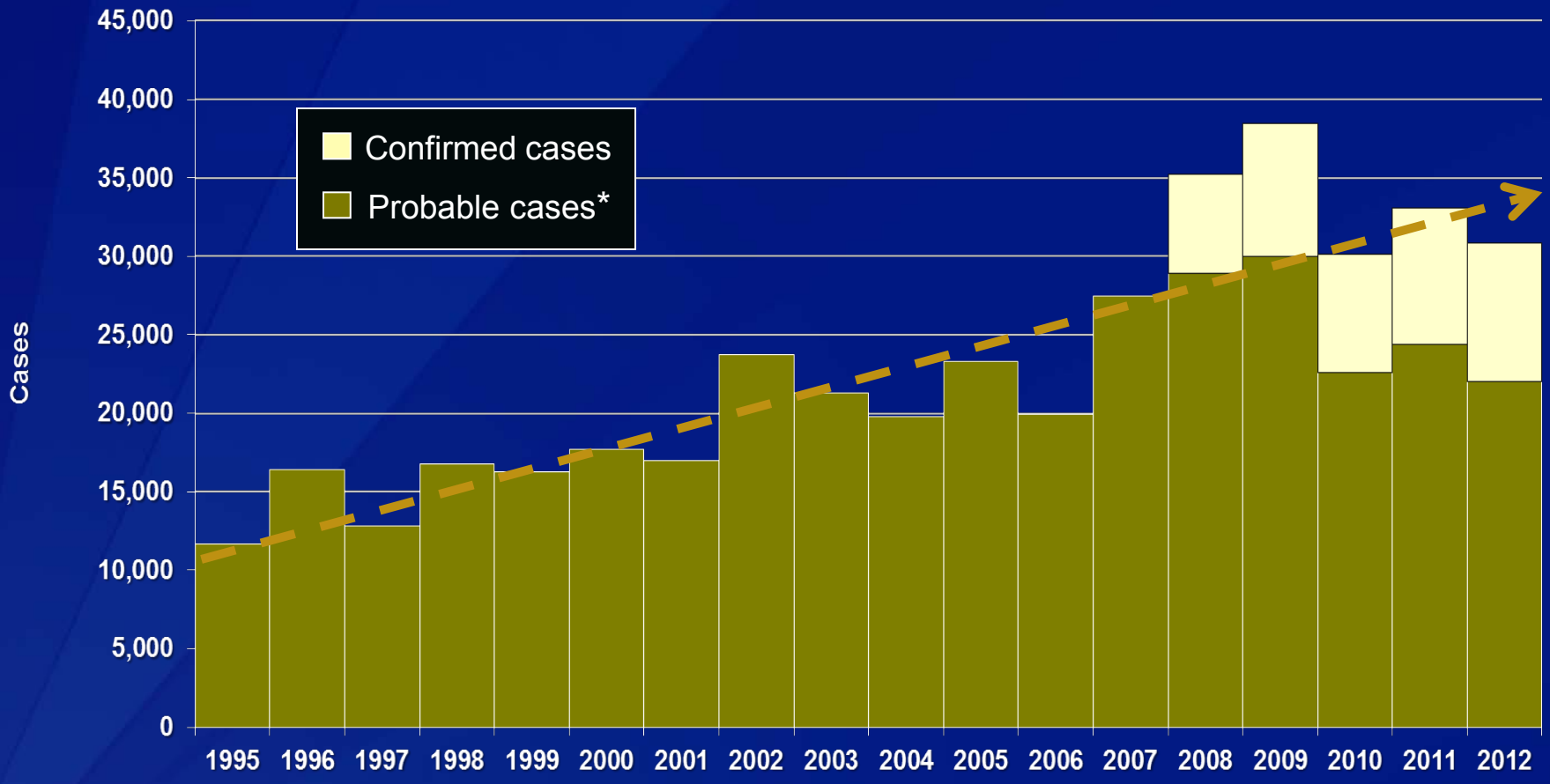
Young & Delleker sc. -- Philadelphia : *Anthony Finley.*
Scan courtesy of University of Connecticut, UConn Libraries

# Top 10 Notifiable Diseases in the United States, 2012

| Disease | Case numbers |
|---|---|
| 1. Chlamydia | 1,422,976 |
| 2. Gonorrhea | 334,826 |
| 3. Salmonellosis | 53,800 |
| 4. Syphilis | 49,903 |
| 5. Pertussis | 48,277 |
| 6. HIV/AIDS (diagnoses) | 35,361 |
| 7. Lyme disease | 30,831* |
| 8. Coccidioidomycosis | 17,802 |
| 9. Invasive Pneumococcal disease | 17,138 |
| 10. Shigellosis | 15,528 |

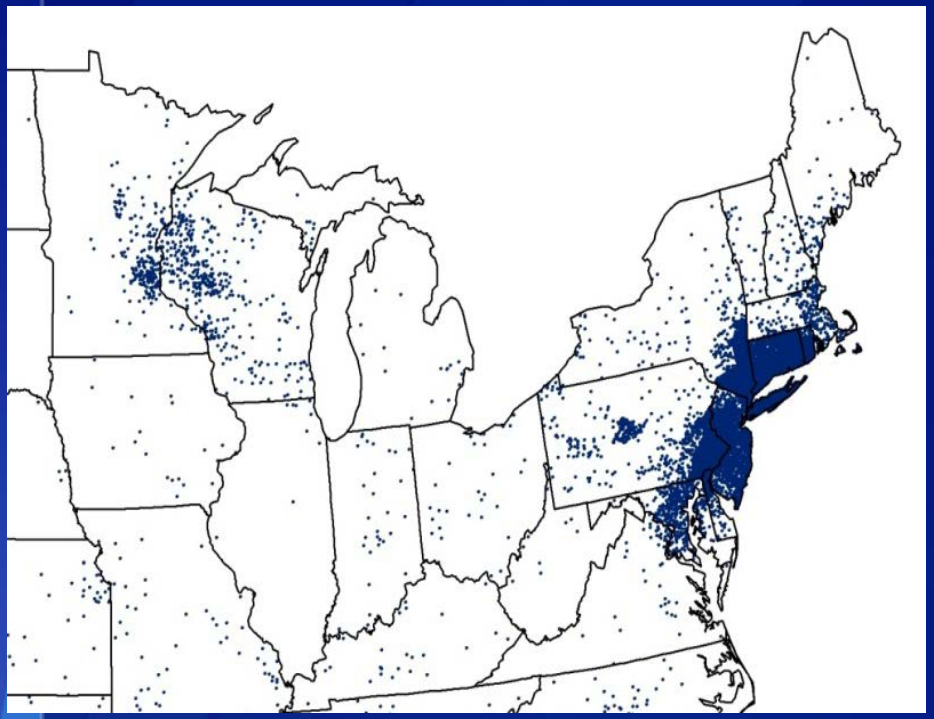
*Underreported by an estimated 10-fold

# Reported Cases of Lyme Disease by Year, United States, 1995-2012

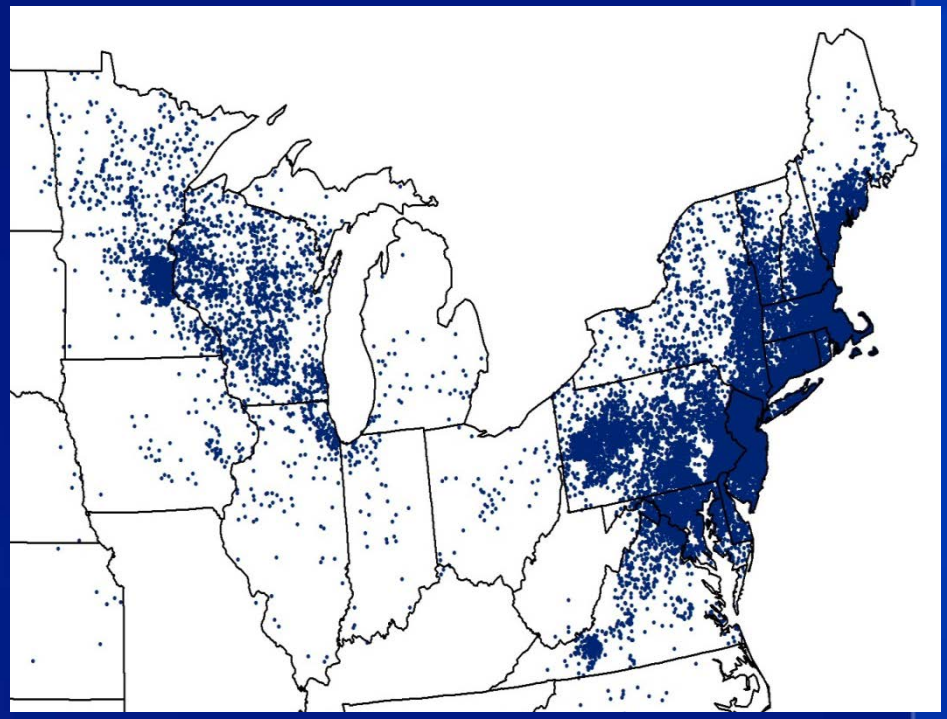



*National Surveillance case definition revised in 2008 to include probable cases; details at http://www.cdc.gov/ncphi/disss/nndss/casedef/lyme_disease_2008.htm

# Lyme Disease U.S. Case Distribution – 17 year Trend



1996



2012

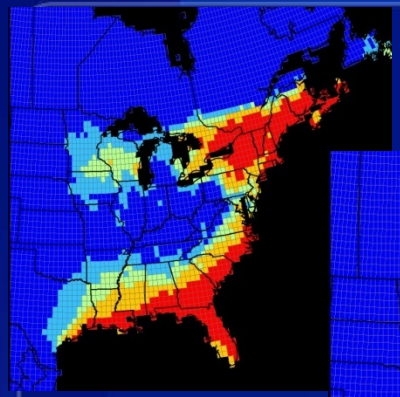
http://www.cdc.gov/lyme/stats/maps/interactiveMaps.html

# Tick-borne Diseases in the United States, 2003-2012

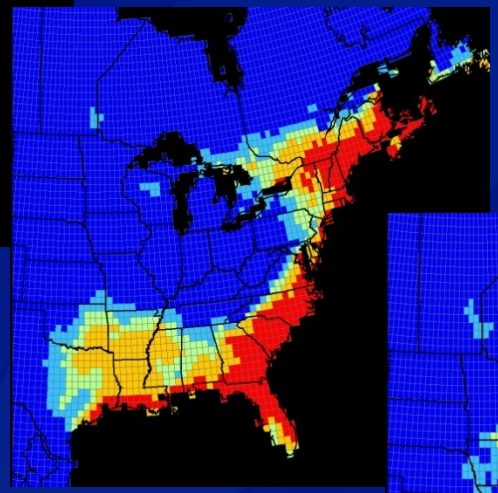
| Disease | Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| Lyme | 21,273 | 19,859 | 21,304 | 19,931 | 27,444 | 35,198 | 38,468 | 30,158 | 33,097 | 30,831 |
| RMSF | 1,091 | 1,738 | 2,029 | 2,288 | 2,221 | 2,563 | 1,815 | 1,985 | 2,802 | 4,470 |
| Eh/An (total)* | 727 | 934 | 1,404 | 1,455 | 1,999 | 2,107 | 2,267 | 2,615 | 3,586 | 3,725 |
| Babesia‡ | | | | | | | | | 1,128 | 940 |

*Includes HGA, HME, and other or unspecified ehrlichiosis
‡Babesiosis became nationally notifiable in 2010

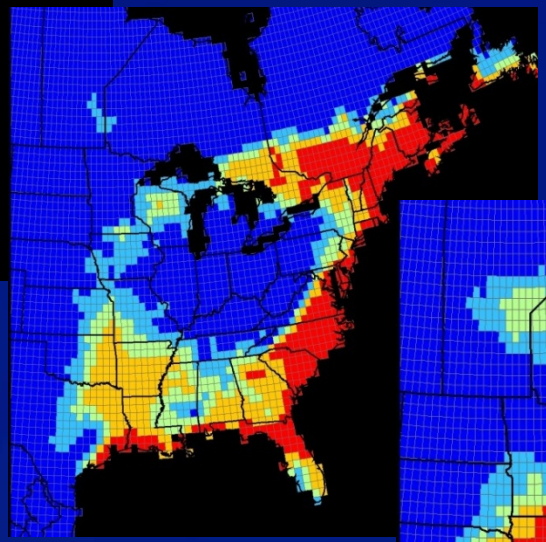
# Projected Distribution of *Ixodes scapularis*



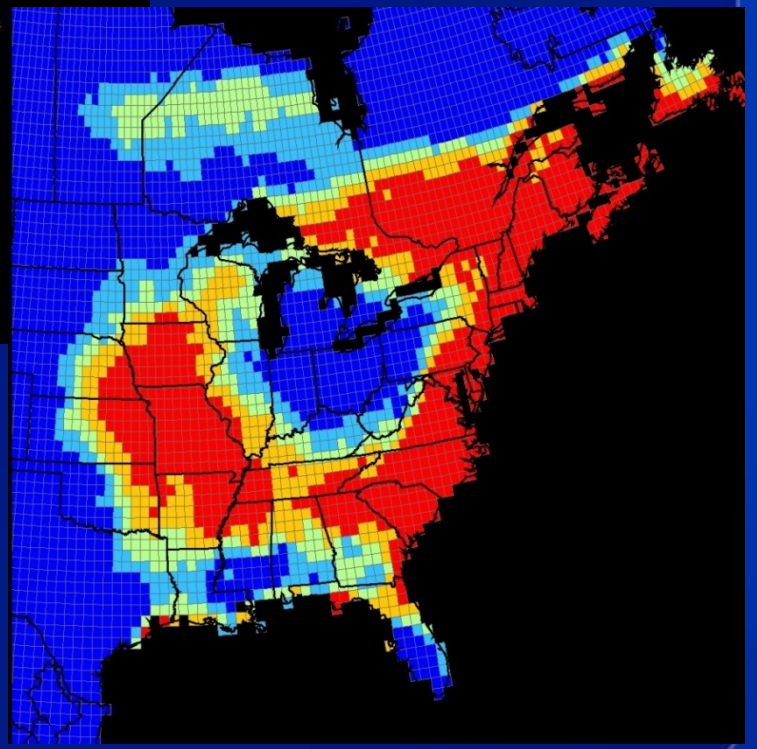
PRESENT



2020



2050



2080

Based upon CGCM1 Climate Change Model

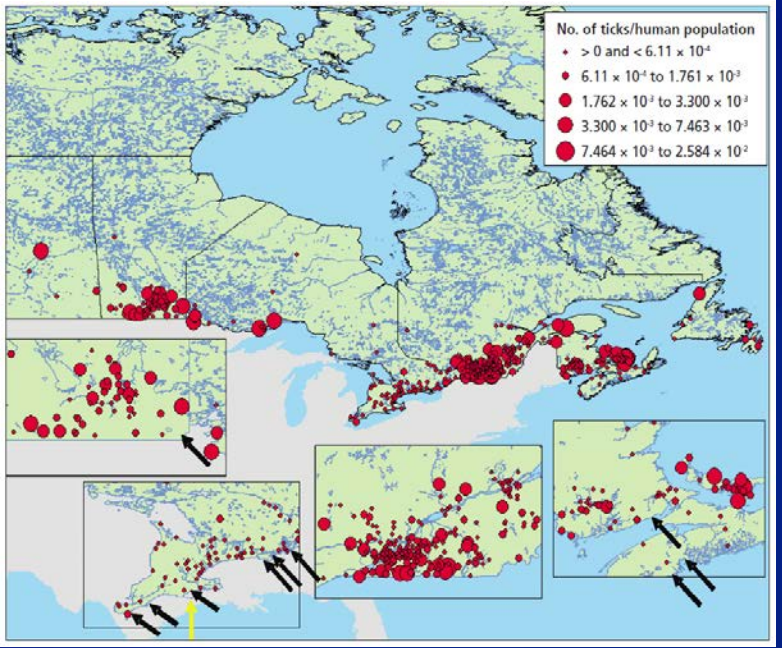
Brownstein et al. 2005 EcoHealth 2: 38-45

# Lyme Disease Northward Expansion into Canada

CMAJ REVIEW

## The emergence of Lyme disease in Canada

Nicholas H. Ogden DPhil, L. Robbin Lindsay PhD, Muhammad Morshed PhD, Paul N. Sockett PhD, Harvey Artsob PhD



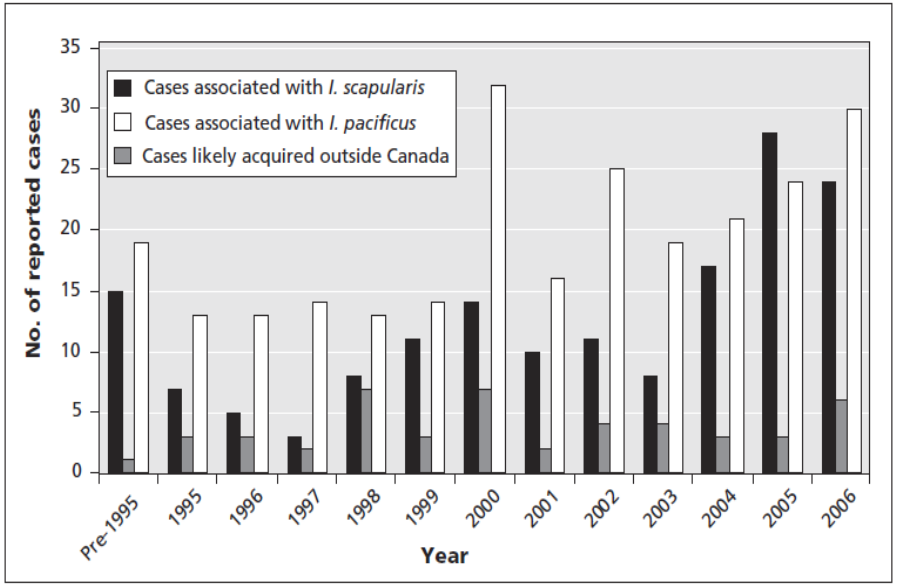
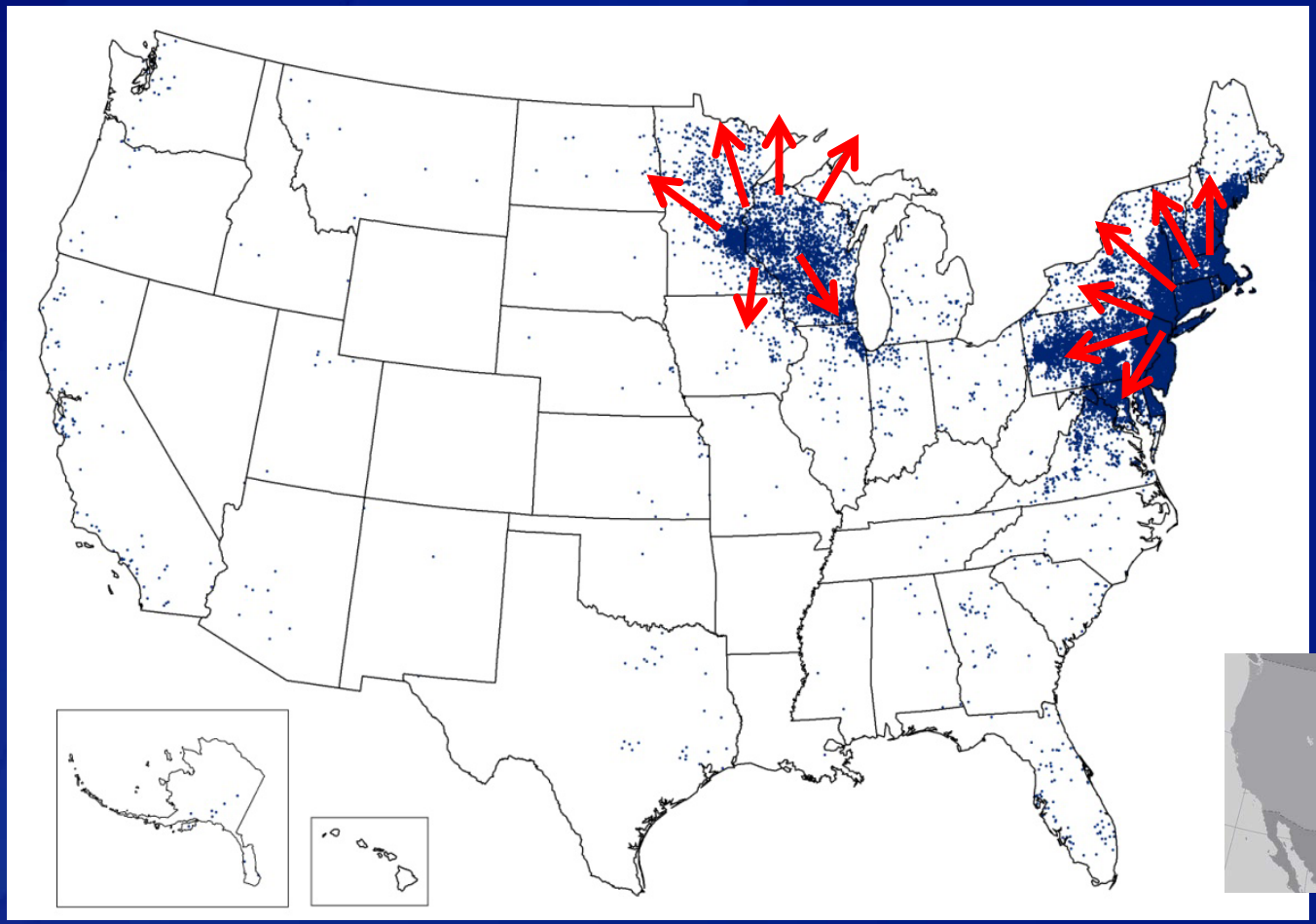
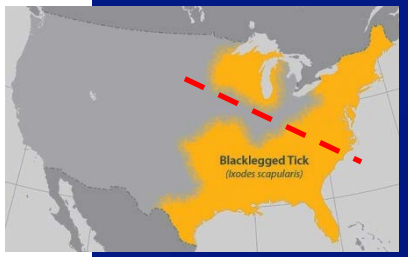




Figure 3: Annual number of cases of Lyme disease reported voluntarily by the provinces and territories since the late 1980s. Cases of Lyme disease in British Columbia were probably transmitted by *Ixodes pacificus*, whereas cases from all other provinces with cases that were potentially locally acquired (i.e., Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia and Newfoundland and Labrador) were probably associated with *Ixodes scapularis*. Cases affecting patients with a history of travel to an endemic area outside Canada during the period when they likely acquired the infection are considered travel-related or nonendemic. Reproduced with permission from the Minister of Public Works and Government Services Canada, 2008.[15]

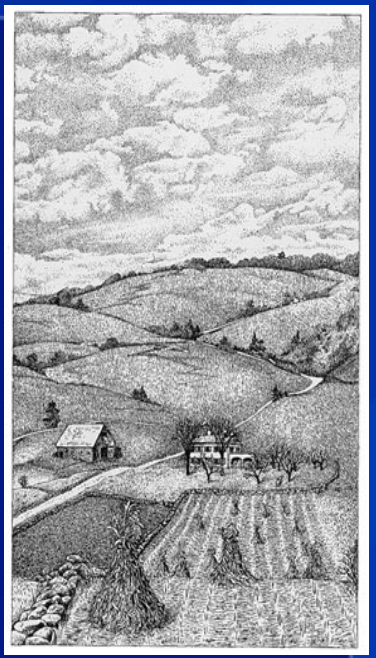
# Reported Cases of Lyme Disease in the United States – 2011



1 dot placed randomly within county of residence for each confirmed case



# Lyme Disease Emergence and Changing Land Use Patterns (1860s – 1980s)



**Source:**

Bald hills: New England before the trees returned. From *Thoreau's Country*.

American Scientist Online

Http://www.amercanscientist.org

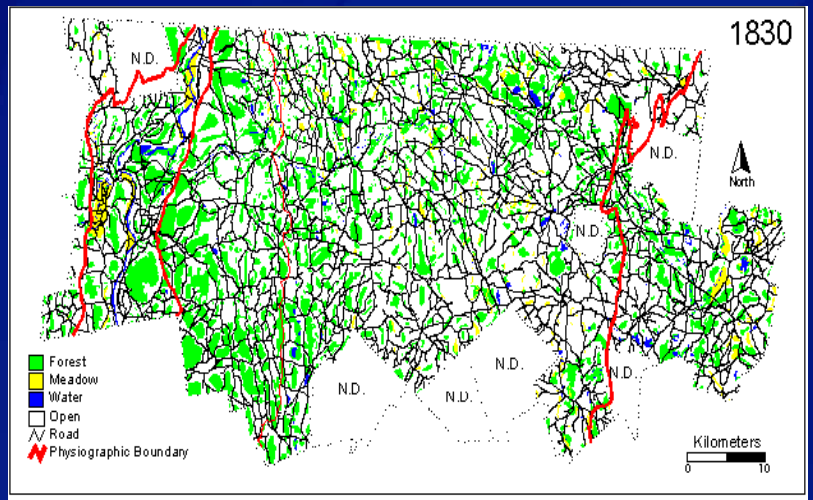
Chipman Hill, Middlebury, Vt., 1860s

Chipman Hill, 1900s

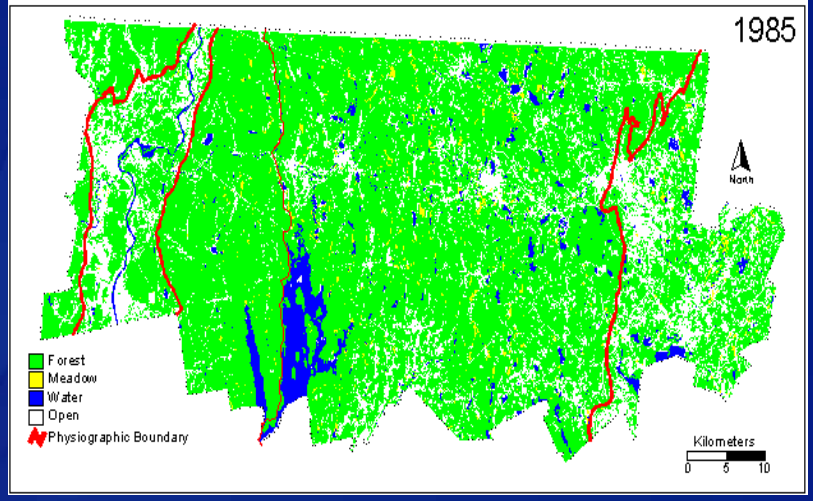
Chipman Hill, 1980s

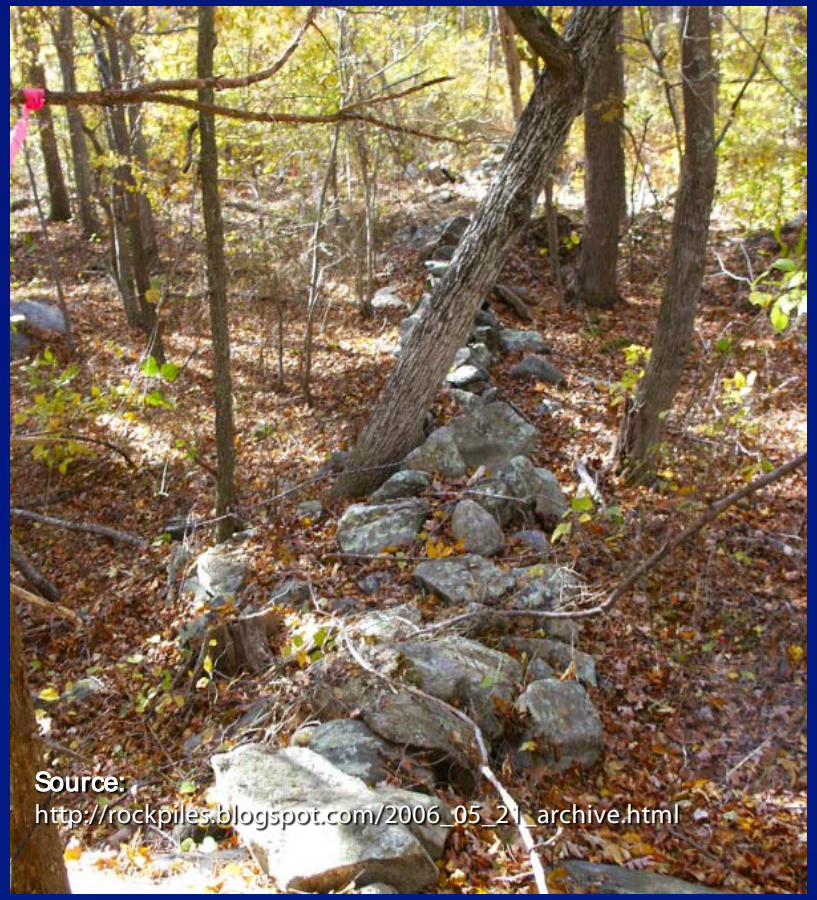
**Source:** Henry Sheldon Museum - http://henrysheldonmuseum.org

# Lyme Disease – Emergence



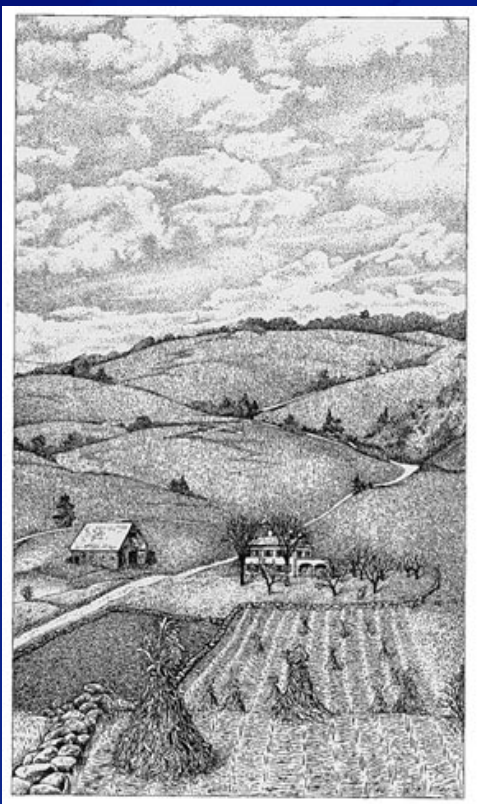

**Source:**
http://biology.usgs.gov/luhna/harvardforest.html




"In Connecticut, the number of deer has increased from about 12 in 1896 to 76,000 today." [Kirby Stafford Connecticut Agriculture Experiment Station]

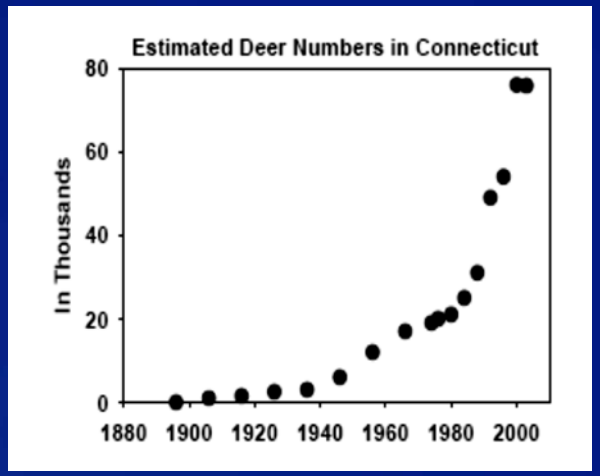
# Tick-borne Disease Emergence – Re-emergence in the U.S.



Source:

Bald hills: New England before the trees returned. From *Thoreau's Country.*

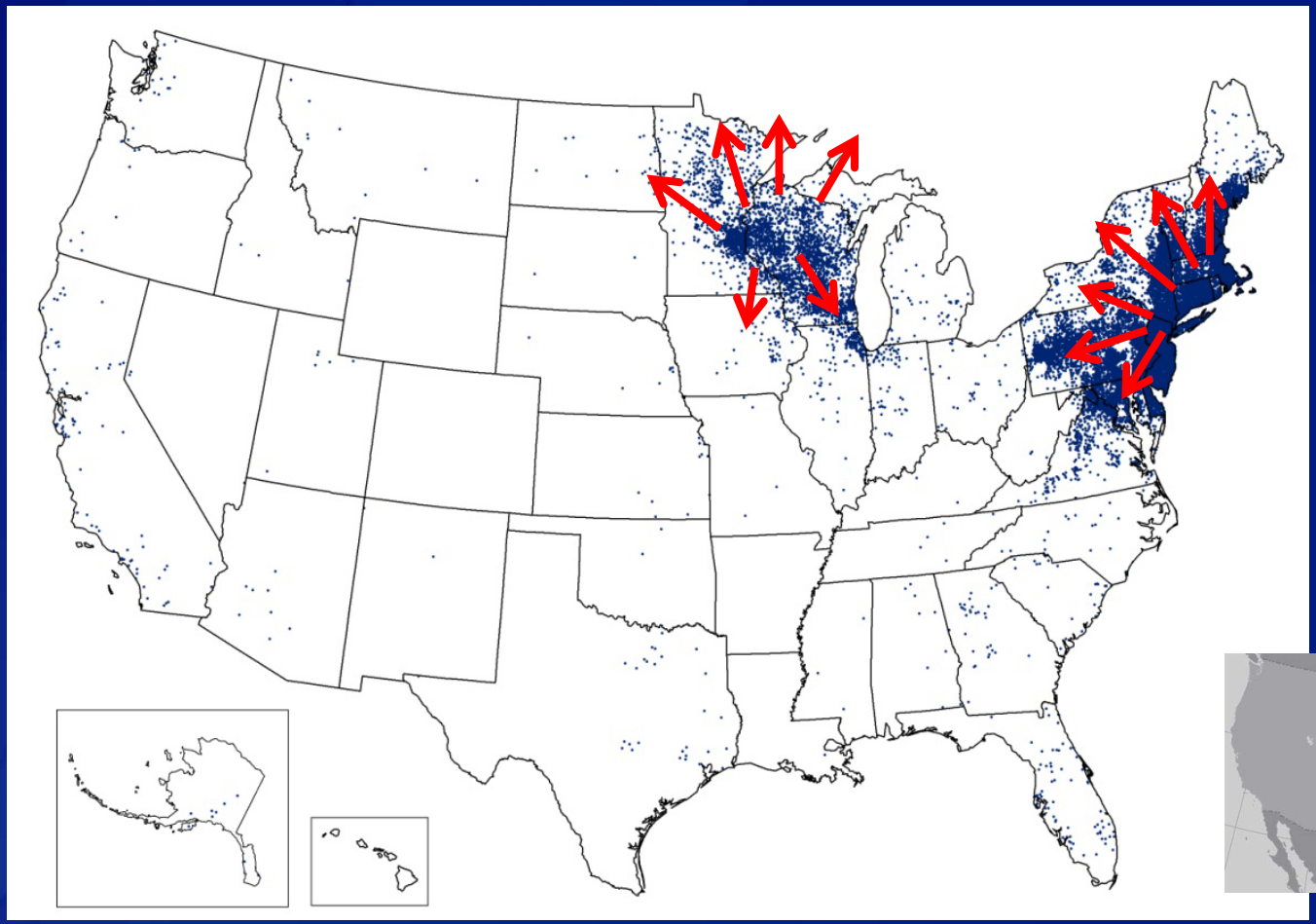
American Scientist Online
Http://www.amercanscientist.org



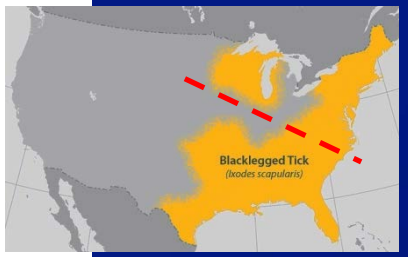

- Reforestation
- Overabundant deer
- Increased numbers of ticks
- Expansion of suburbia into wooded areas
- Increased exposure opportunities
- Changes in diagnostic, surveillance, and reporting practices

Source: K. Stafford, CT Agricultural Experiment Station

# Reported Cases of Lyme Disease in the United States – 2011



1 dot placed randomly within county of residence for each confirmed case



# Lyme Disease Expansion – Southward

| | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Delaware | 77 | 167 | 167 | 152 | 194 | 212 | 339 | 646 | 482 | 715 | 772 |
| Maryland | 659 | 899 | 688 | 608 | 738 | 691 | 891 | 1235 | 1248 | 2576 | 2218 |
| Virginia | 73 | 122 | 149 | 156 | 259 | 195 | 216 | 274 | 957 | 959 | 933 |

## New evidence leads officials to affirm Lyme risk in N.C.

### Warning about tick-borne disease

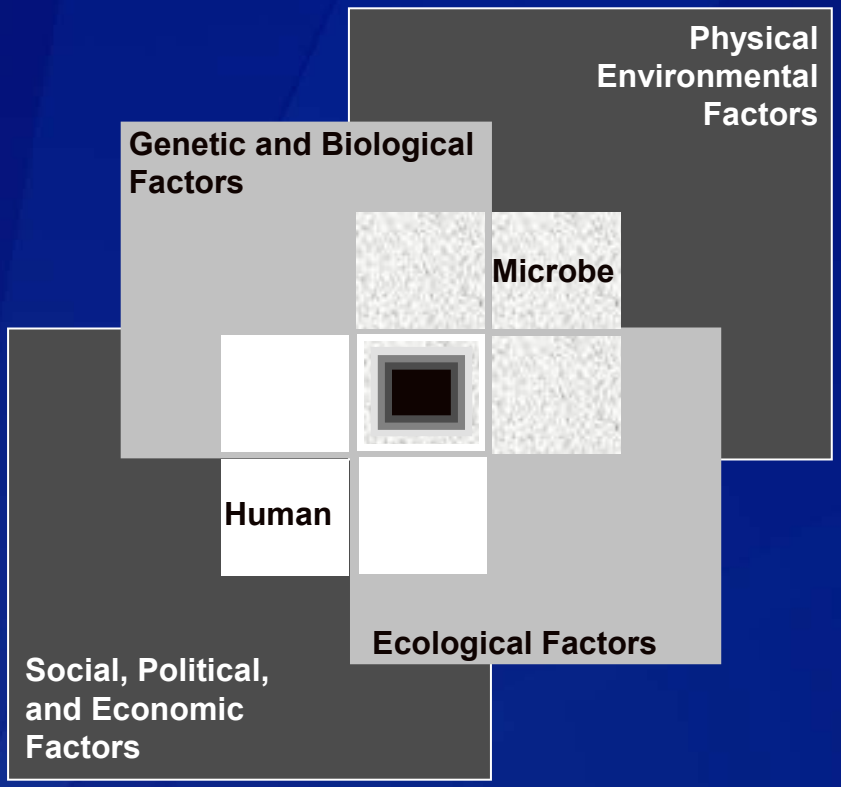
By Sarah Avery
savery@newsobserver.com

Posted: Friday, Oct. 02, 2009

After years of cautioning that people were unlikely to get Lyme disease in North Carolina, state health leaders are now advising that the tick-borne illness can, in fact, be acquired here.

Based on the new evidence, Dr. Megan Davies, state epidemiologist, said the state is now working to get the word to doctors, who for years were reluctant to even test patients for Lyme because it wasn't considered much of a possibility.

# Factors Influencing Disease Emergence (Institute of Medicine 2003 report – *Microbial Threats to Health*)




Convergence Model for Emerging Diseases

- Microbial adaptation and change
- Human susceptibility to infection
- Climate and weather
- Changing ecosystems
- Economic development and land use
- Human demographics and behavior
- Technology and industry
- International travel and commerce
- Breakdown of public health measures
- Poverty and social inequality
- War and famine
- Lack of political will
- Intent to harm

# Climate Change and Public Health

## Primary need: An anticipatory framework that emphasizes three likelihoods . . .

1. A significant increase in the frequency of severe weather-related crises
2. Temporal and geographic changes in the current distribution of adverse events requiring public health preparedness and response
3. Stress leading to potential failure of government structures and services that are aging and in need of repair, such as highways, bridges, and energy, sewage and water delivery systems.

# Climate Change and Public Health

Specific Research Needs…

- Long-term surveillance on climate change and the impact on disease ecology and epidemiology
- Integrated data systems with comparable scales
- Models that predict the potential impact of long term climate change and short term climate disruption
- Knowledge of what adaptation and mitigation strategies have the greatest potential for success
- Better understanding of potential future challenges
  - Increase in vector populations and distributions
  - Increase in duration of transmission season
  - Exotic introductions
  - More rapid environmental degradation of pesticides
- Resistance management strategies and options, including a greater reliance on validated IPM approaches

# Conclusion

- Vector-borne, zoonotic, and environmentally-associated diseases are significantly affected by climate and are at the forefront of concern over global emerging diseases
- A *One Health* paradigm emphasizes the critical relationship between human health, animal health, and the environment in understanding the drivers of disease emergence
- Complex weather patterns and global climate change directly impact the ecology of vector-borne and zoonotic diseases
- A integrated understanding of climate, ecology, and epidemiology is critical for predicting and averting future epidemics of vector-borne and zoonotic diseases
- The best preparation to prevent, mitigate, and adapt to emerging infectious disease threats related to climate change is to continue our investment in disease surveillance and maintain a strong national public health system so that when diseases occur in new areas, they will be quickly detected and reported, allowing prevention and control activities to be rapidly and effectively mobilized.

# Climate Change and Human Health


Available at: http://www.cdc.gov/climateandhealth/publications.htm

# Thank you for your attention!

# Questions?

The findings and conclusions in this report have not been formally disseminated by the Centers for Disease Control and Prevention and should not be construed to represent any agency determination or policy