

# CDC PUBLIC HEALTH GRAND ROUNDS

## Climate Change and Health From Science to Practice



Accessible Version: [https://youtu.be/6V\\_0JaE2Gz0](https://youtu.be/6V_0JaE2Gz0)

**December 16, 2014**



U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

# Assessing the Impact of Climate Change on Health



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U.S. Department of  
Health and Human Services  
Centers for Disease  
Control and Prevention

# Objectives

- ❑ Summarize findings from 3rd US National Climate Assessment
- ❑ Review evidence for climate change and its impact on human health
- ❑ Describe CDC and partner efforts to prepare for health effects of climate change

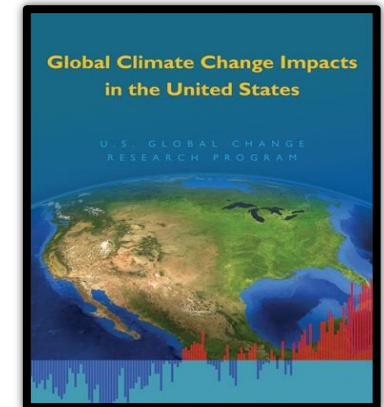


# What is the National Climate Assessment?

- ❑ Established through Global Research Act of 1990
- ❑ Led by White House Office of Science and Technology Policy
- ❑ Authored by experts from academia; local, state, and federal government; private and nonprofit sectors
- ❑ Published previously in 2000 and 2009



2000



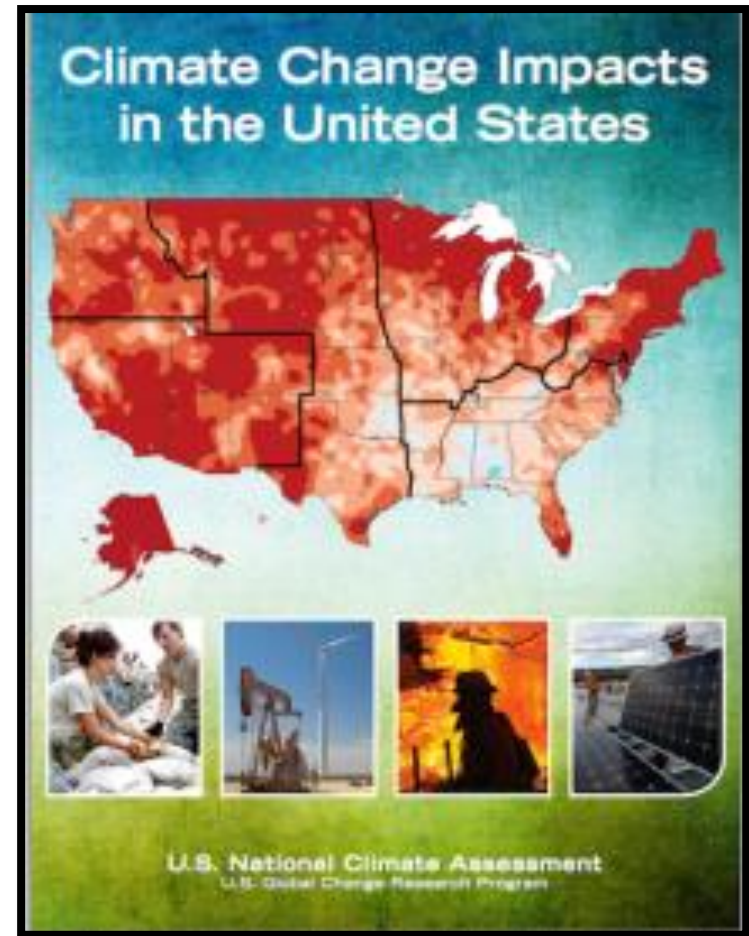
2009

# What are the Goals of the National Climate Assessment?

- ❑ Analyze impact of global climate change on various sectors of society, including public health**
- ❑ Evaluate current trends in human-associated and natural climate change**
- ❑ Project major climate trends in United States for next 25 - 100 years**

# 3rd National Climate Assessment

- ❑ **Published 2014**
- ❑ **Summarizes impacts for many sectors**
  - Public health
  - Energy
  - Water
  - Transportation
  - Agriculture
- ❑ **Represents 3-year effort**
- ❑ **Includes work of 240 authors in 30 chapters**



# 3rd National Climate Assessment Key Findings

## Temperature and Precipitation Impacts

### □ Temperature increases

- Average US temperature has increased by about 1.5°F (0.8°C) since 1895
- Temperatures are projected to rise between 2° to 11.5°F (1.1° to 6.4°C) more by 2100
- Shorter periods of frost since the 1980s

### □ Precipitation changes

- Heavy downpours have increased in most regions of the United States
- More precipitation as rain; less as snow
- In general, wet areas will get wetter, dry areas will get drier

# 3rd National Climate Assessment Key Findings

## Extreme Weather and Ocean Impacts

### □ **Increases in extreme weather events**

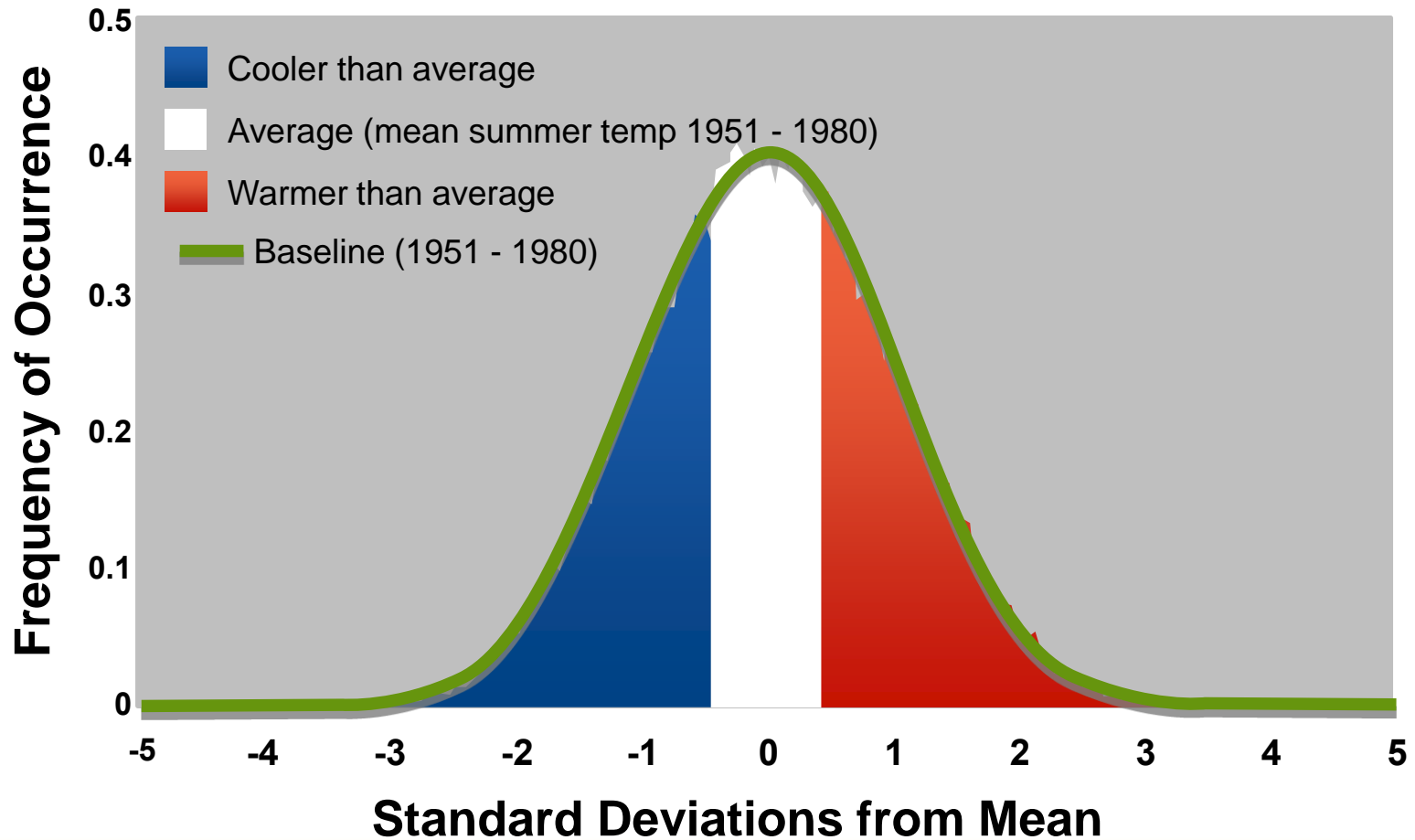
- Heat waves, floods, and droughts have become more frequent and intense
- Number of Category 4 and 5 hurricanes in the North Atlantic has increased since early 1980s

### □ **Impacts on oceans**

- Sea level has risen about 8 inches since 1880
- Sea level is projected to rise another 1 to 4 feet by 2100
- Ocean acidity has increased 26% since the start of the industrial era as a result of the ocean's carbon dioxide absorption

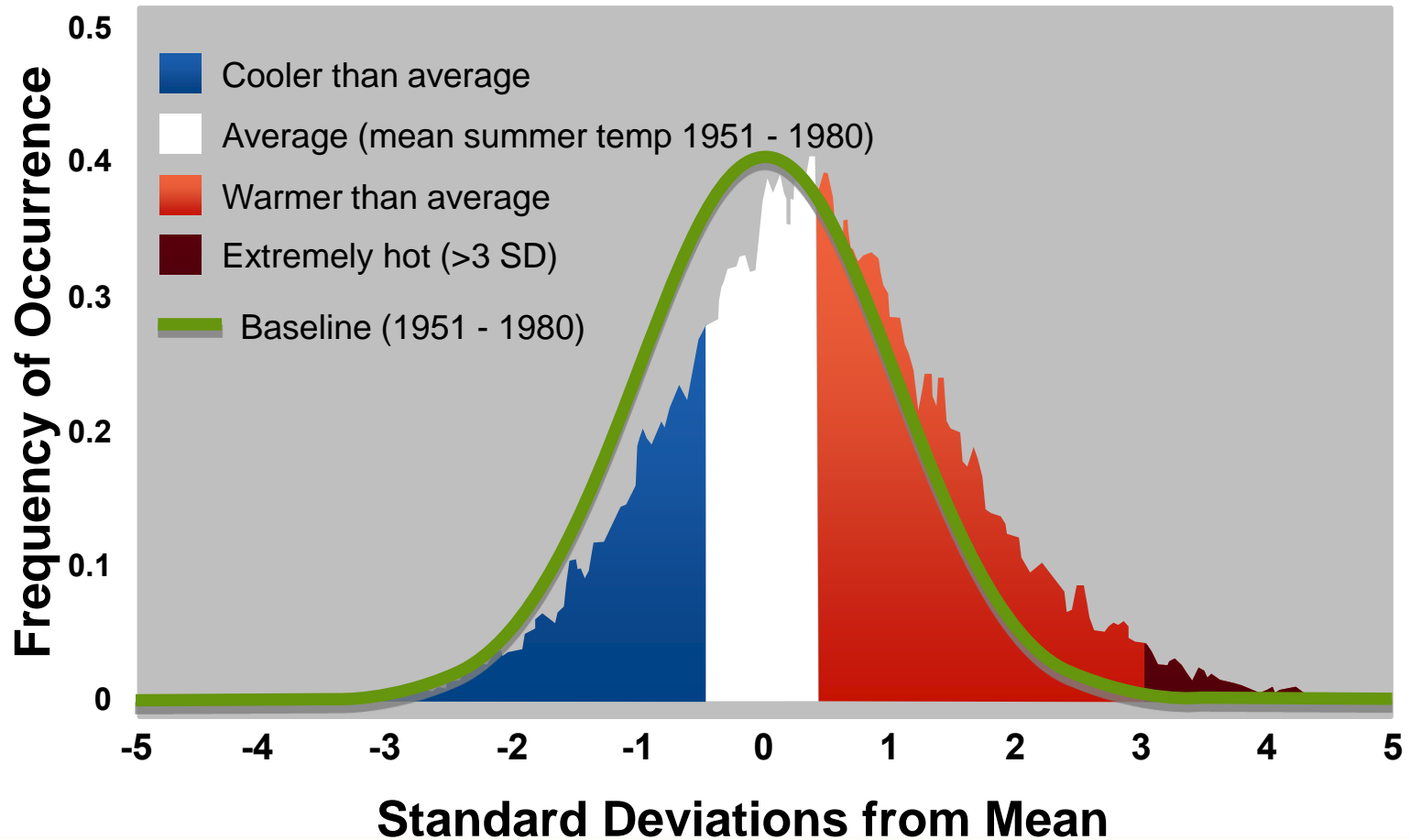


# Average Summer Temperatures 1951–1980



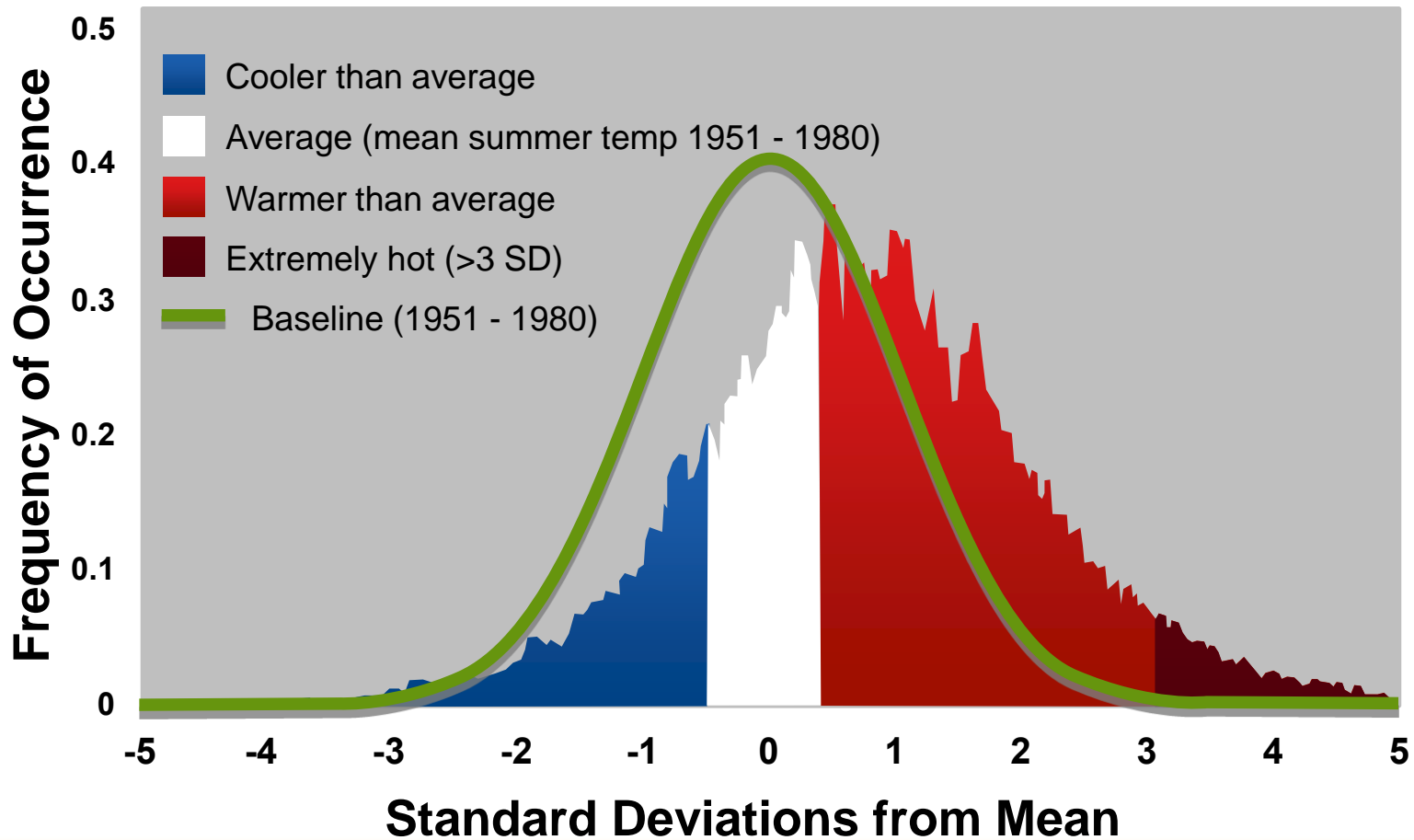
NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012

# Average Summer Temperatures 1981–1991



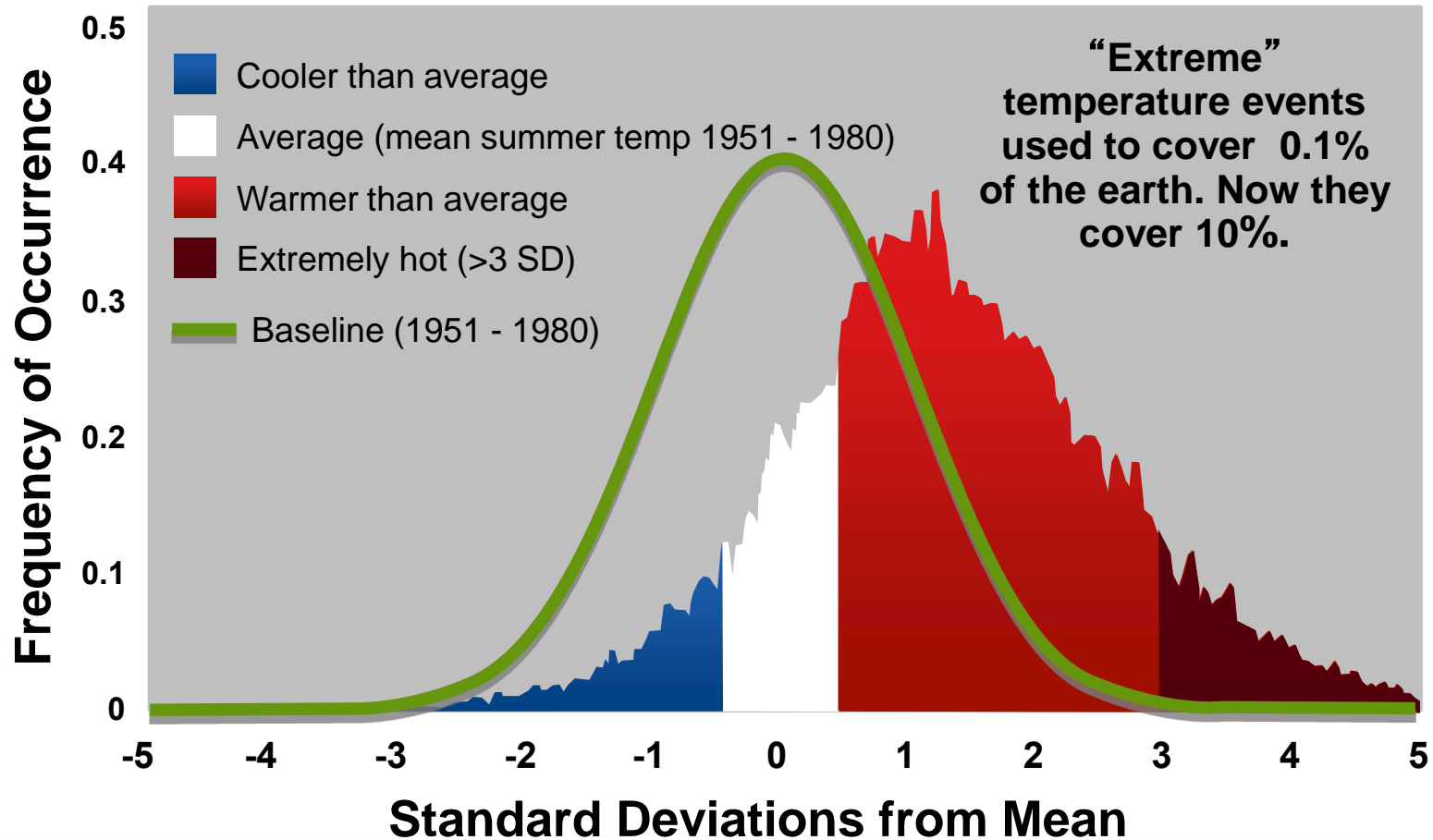
NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012  
SD: standard deviation

# Average Summer Temperatures 1991–2001



NASA/GISS; Hansen, et al., "Perceptions of Climate Change," Proc. Natl. Acad. Sci. USA 10.1073, August 2012  
SD: standard deviation

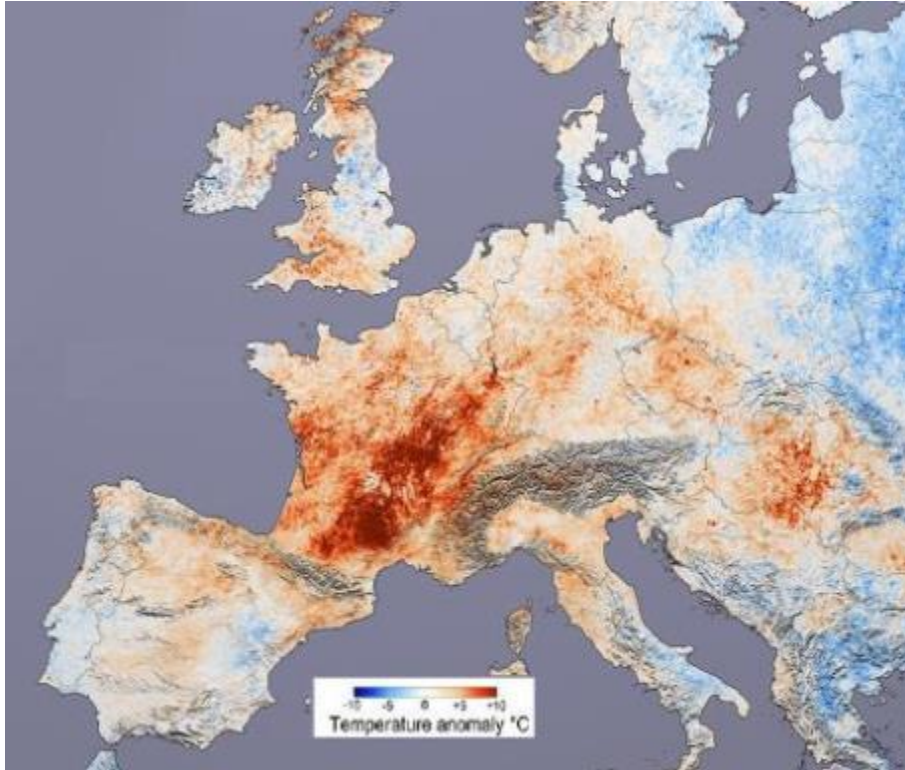
# Average Summer Temperatures 2001–2011



NASA/GISS; Hansen, et al., “Perceptions of Climate Change,” Proc. Natl. Acad. Sci. USA 10.1073, August 2012  
SD: standard deviation

# Heat Waves Are Deadly

## European Heat Wave of 2003



## Confirmed Mortality

UK	2,091
Italy	3,134
France	14,802
Portugal	1,854
Spain	4,151
Switzerland	975
Netherlands	1,400 - 2,200
Germany	1,410
<hr/>	
<b>TOTAL</b>	<b>29,817 - 30,617</b>

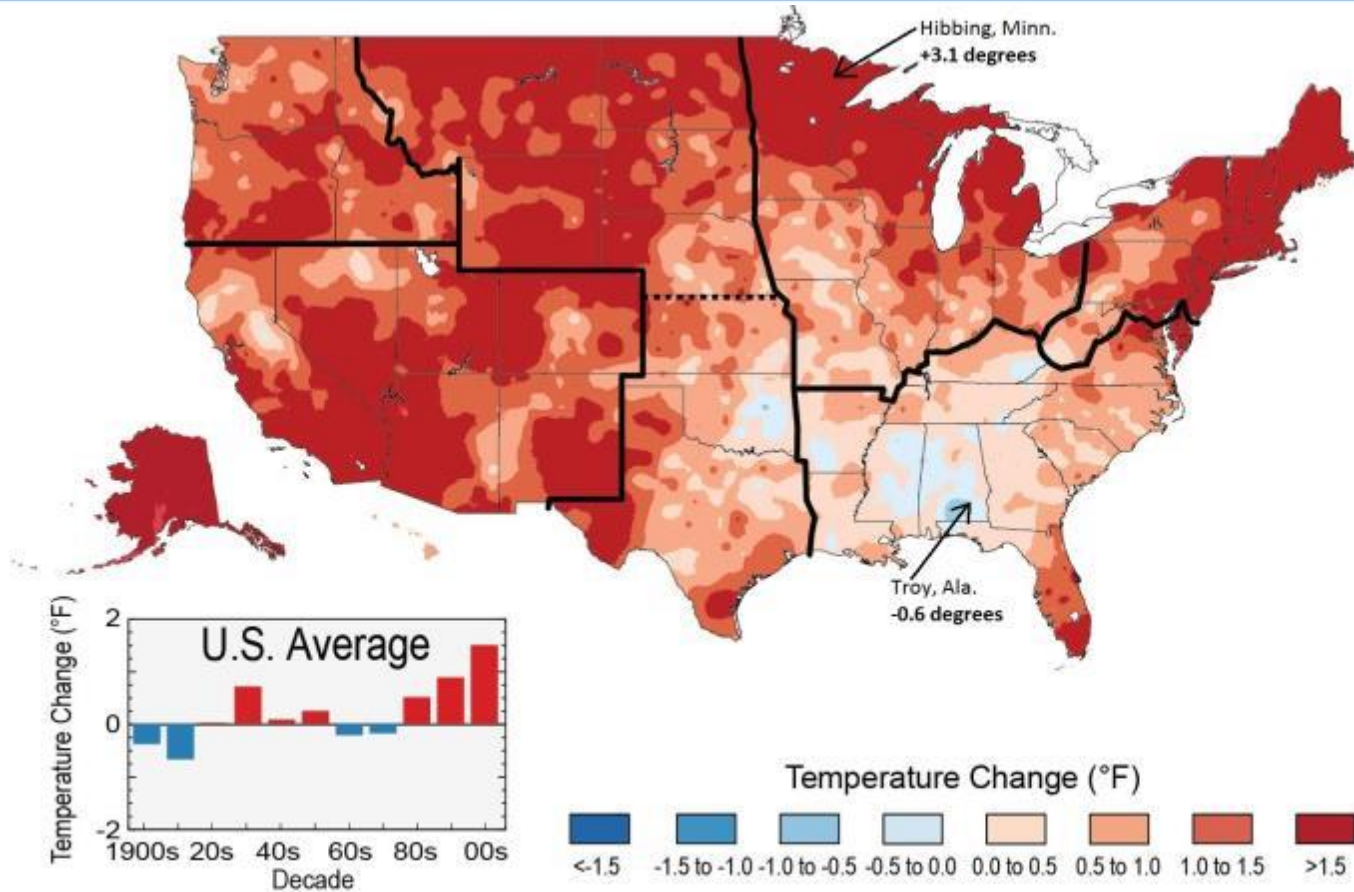
**Excess (all-cause) mortality was double the confirmed mortality**

Vandentorren et al. *Am J Public Health* 2004; 94(9):1518-20.

Haines et al. *Public Health* 2006;120:585-96.

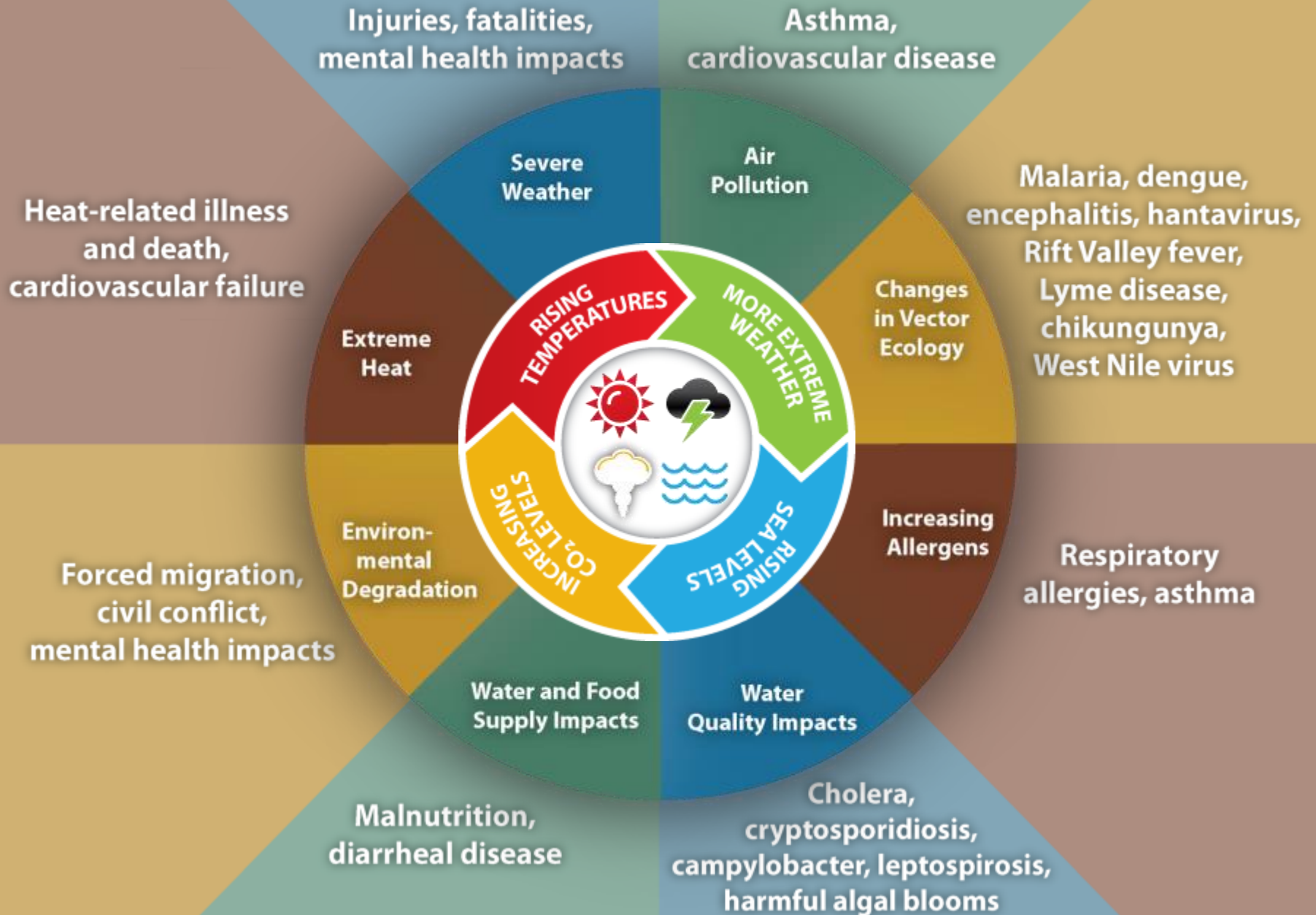
UK: United Kingdom

# Warming Has Varied Significantly By Region



**1991 - 2012 average temperature compared with 1901 - 1960 average**

# Impact of Climate Change on Human Health



# Climate Change Effects on Health: A Multifaceted Problem



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Natural Resources Defense Council*



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# Effect of Climate Change on Health



**In a 2014 National Medical Association survey, 61% of physicians reported their patients' health has been affected by climate change**

# Key Message 1: Wide-ranging Health Impacts

- ❑ **Climate change threatens human health and well-being in many ways, including**
  - Impacts from increased extreme weather events, wildfire, and decreased air quality
  - Threats to mental health
  - Illnesses transmitted by food, water, and disease carriers such as mosquitoes and ticks
  
- ❑ **Some of these health impacts are already happening in the United States**

# Rising Temperatures Projected to Worsen Asthma by the 2020s

## Estimated Increase in Ozone-related Emergency Room Visits for Children in 14 New York Counties

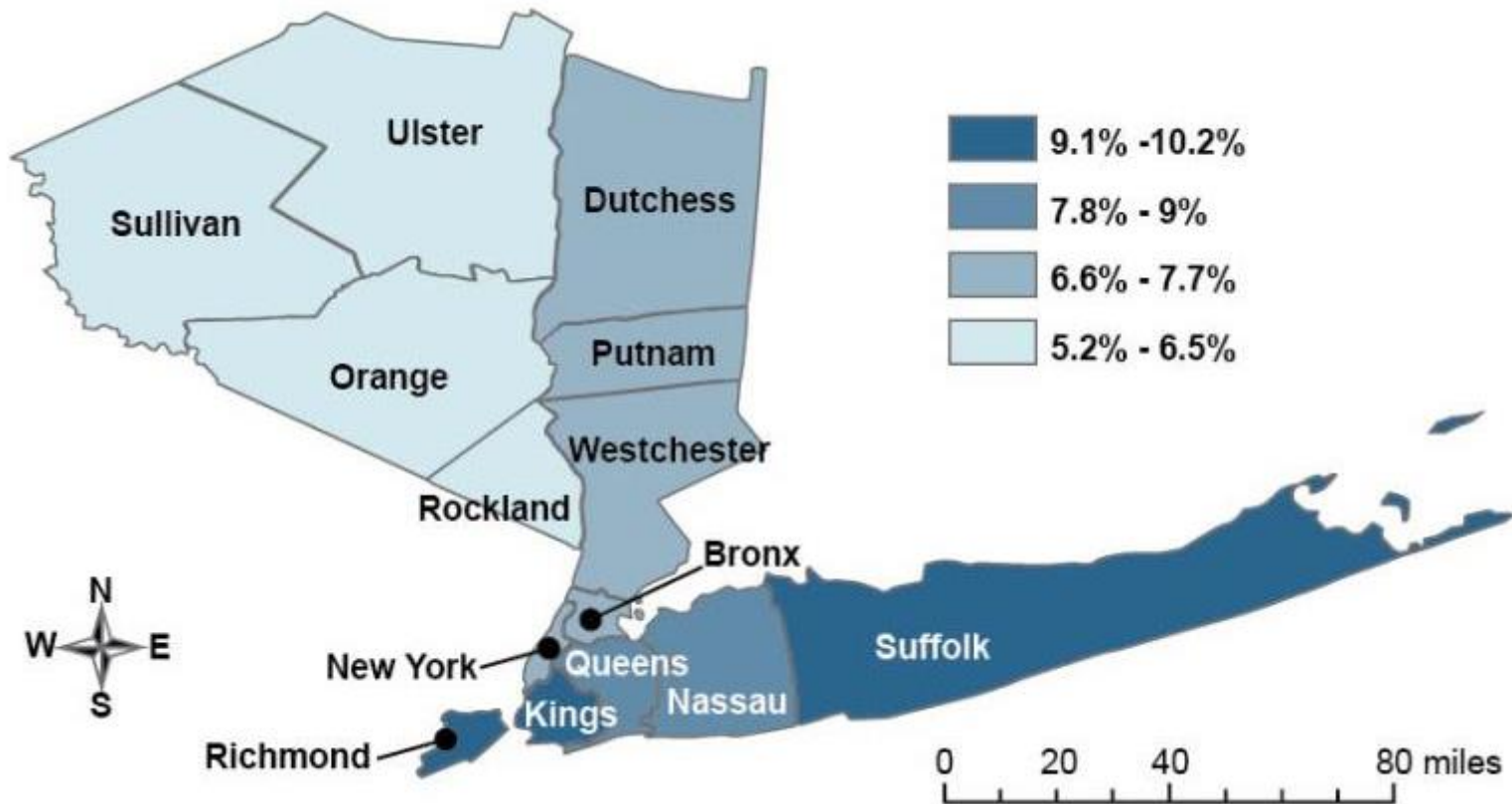


Figure 9.1, Health chapter, NCA3 [from Sheffield et al. 2011]; USGCRP, 3rd National Climate Assessment, Downloads and Materials, available at: [www.globalchange.gov/nca3-downloads-materials](http://www.globalchange.gov/nca3-downloads-materials)

# Health Effects of Climate Change: Longer Ragweed Pollen Seasons, 1995-2011

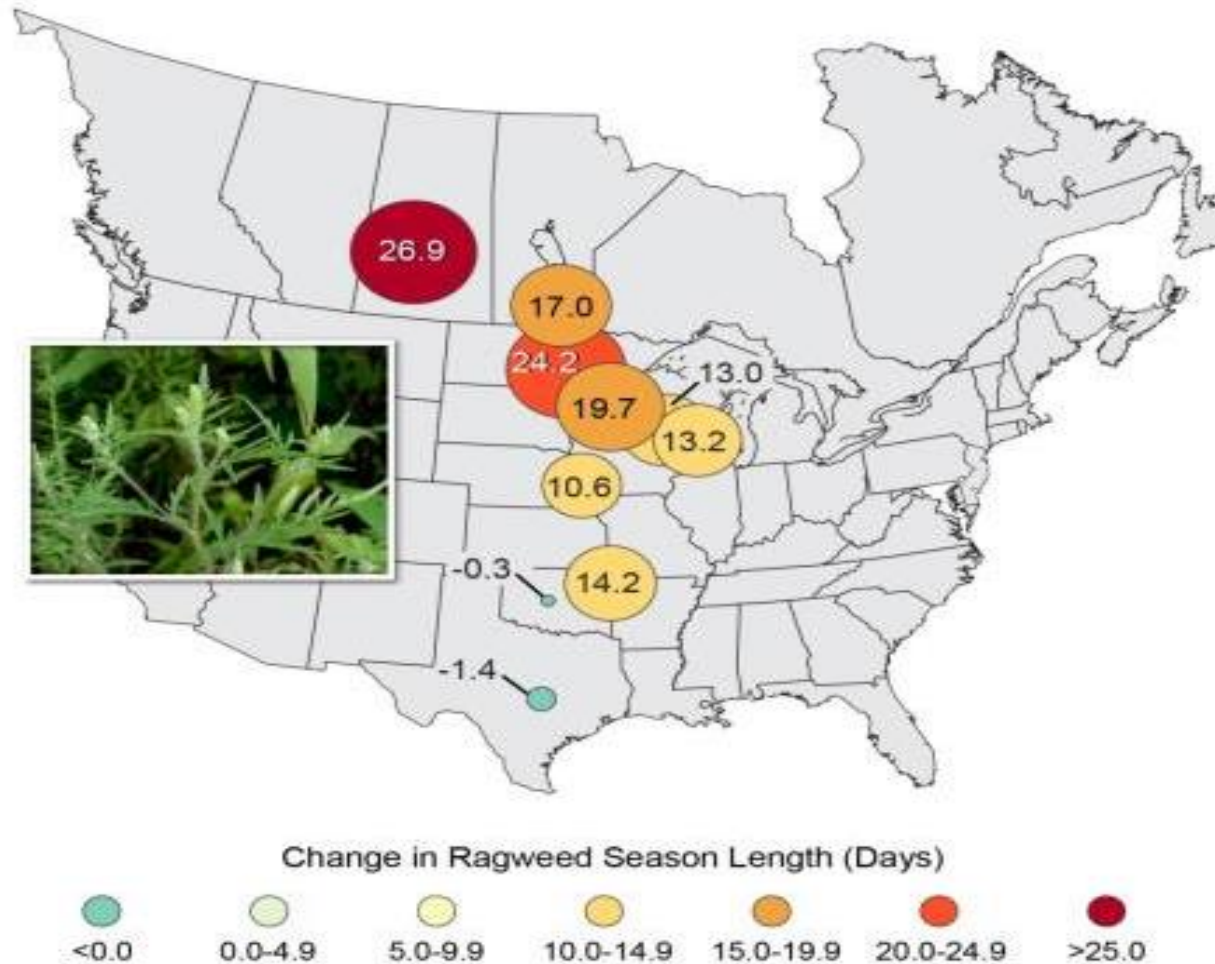


Figure 9.2, Health chapter, NCA3 (from Ziska et al. 2011)  
Photo: Lew Ziska

# Wildfire Smoke Increases Airborne Fine Particle Concentrations



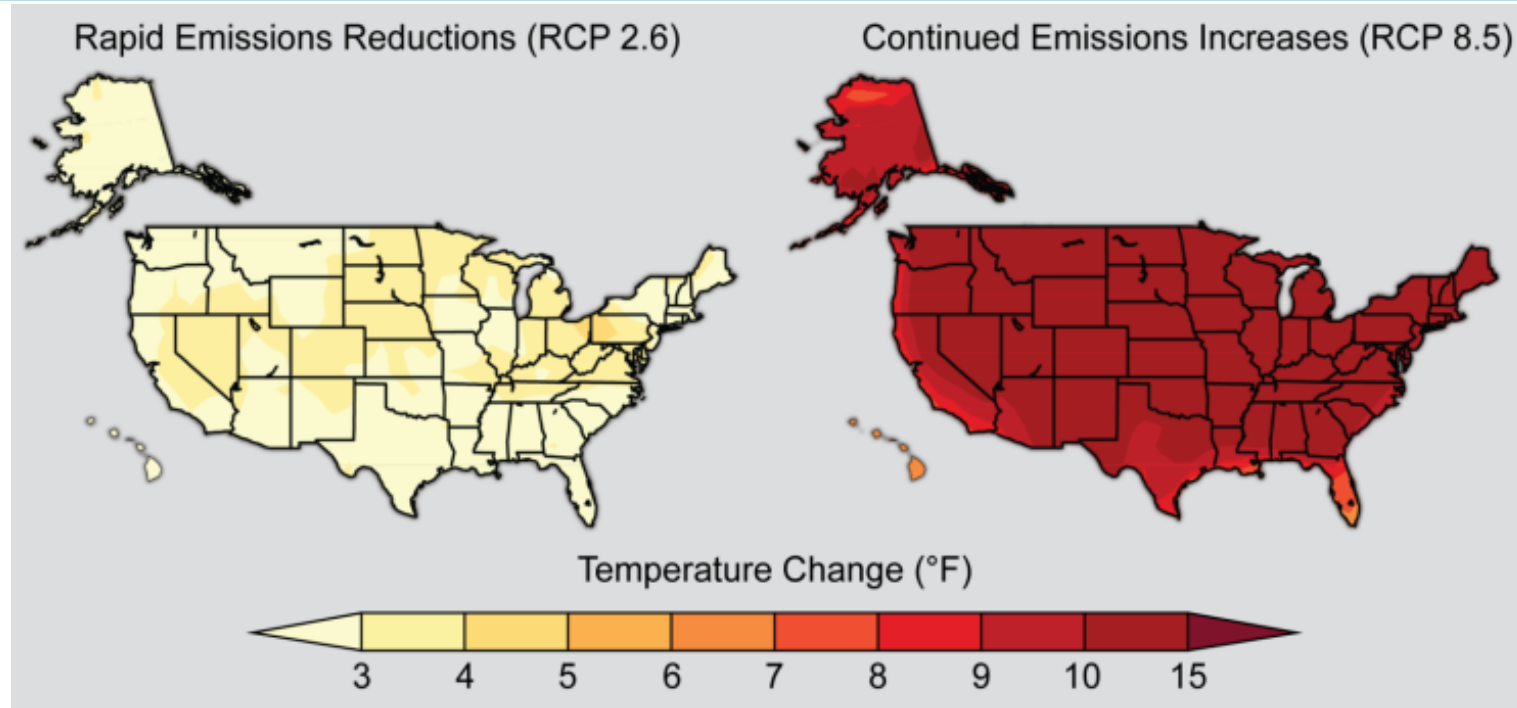
← **Wildfires in Quebec, 2002**

Total deaths from effects of  
landscape fire smoke  
~ 260,000-600,000 persons  
annually, worldwide

← **Increased harmful fine  
particle levels in Baltimore**

Figure 9.3, NCA3 Health chapter [Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on the Terra satellite, Land Rapid Response Team, NASA/GSFC. From Sapkota et al. 2002 and Kinney 2008

# By 2090, the Hottest Days Will Get Even Hotter



**Heat waves can result in increased hospitalizations and deaths (e.g., Chicago, 1995)**

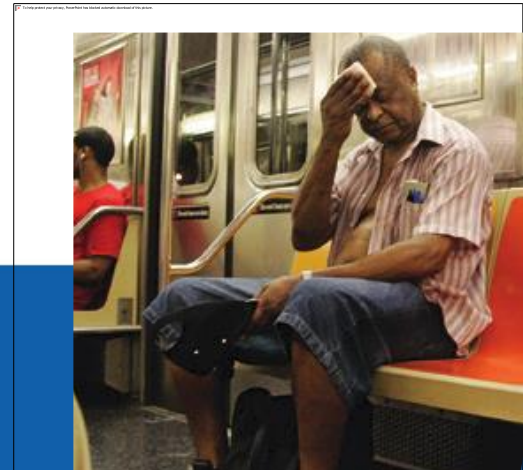
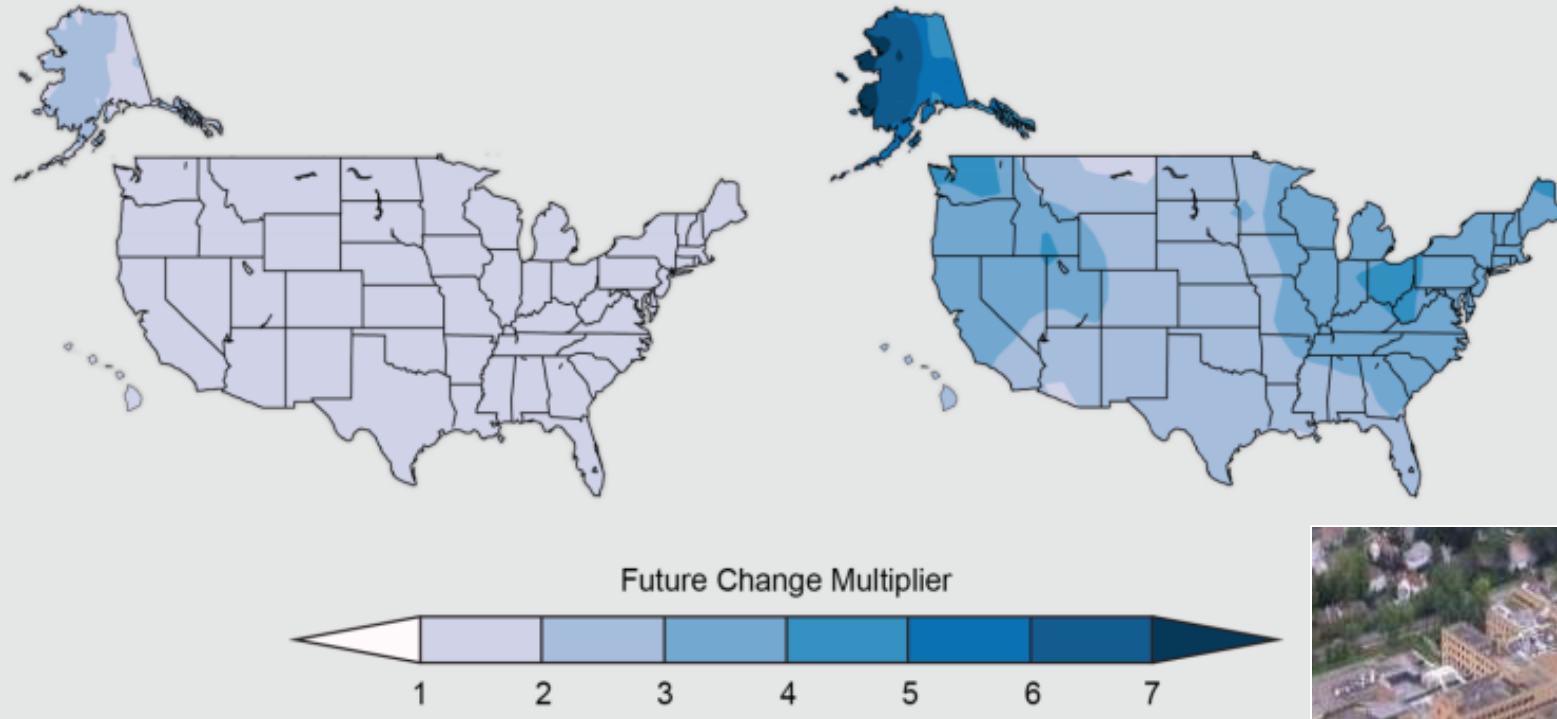


Figure 9.4, Health chapter NCA3; NOAA NCDC / CICS-NC  
RCP: Representative Concentration Pathways

# Increases in Heavy Precipitation Events and Flooding by 2090

Rapid Emissions Reductions (RCP 2.6)

Continued Emissions Increases (RCP 8.5)



**Flooding of Lourdes Hospital,  
Binghamton NY, 2006**

Figure 9.6, Health chapter NCA3; NOAA NCDC/CICS-NC  
Photo: Floodbreak

# Heavy Downpours Increase Exposure to Waterborne Diseases

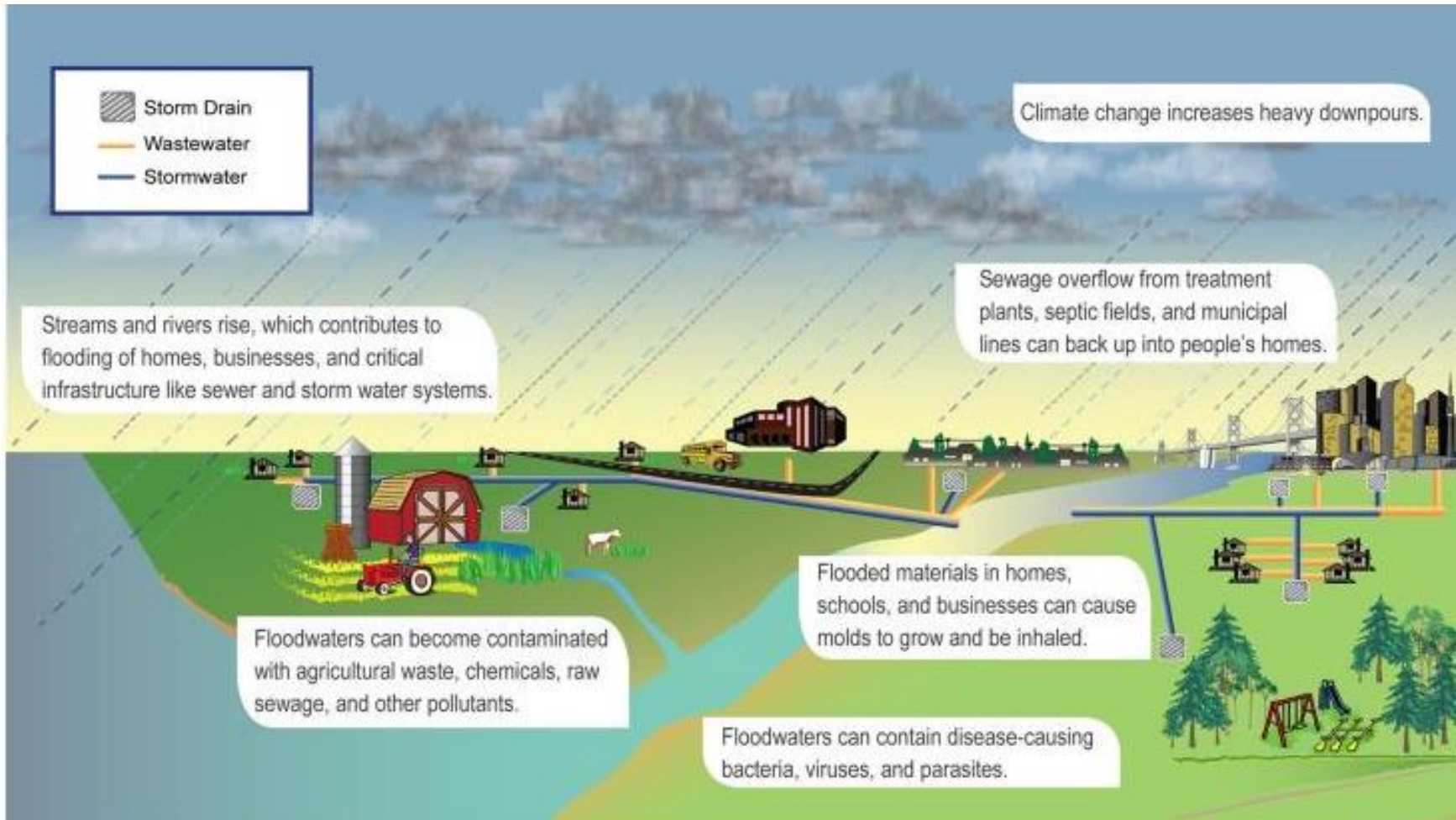


Figure 9.7, Health chapter NCA3; NOAA NCDC/CICS-NC



# Increase in Harmful Algal Blooms: Effects on Drinking Water Safety

## Harmful bloom of algae, Lake Erie, 2011



# Key Message 2: Most Vulnerable at Most Risk

- ❑ **Absent other changes, climate change will amplify existing health threats the nation faces**
- ❑ **Certain people and communities are especially vulnerable:**

- **People**

- **Under age 5**
- **Age 65 and older**
- **With chronic health conditions**

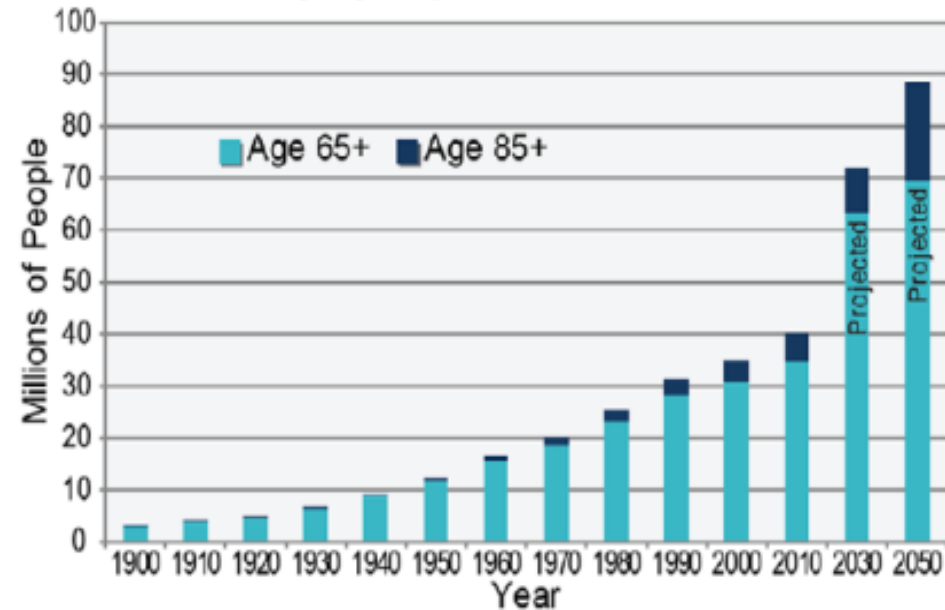
- **Places**

- **River and coastal floodplains**
- **Urban “heat island” areas**



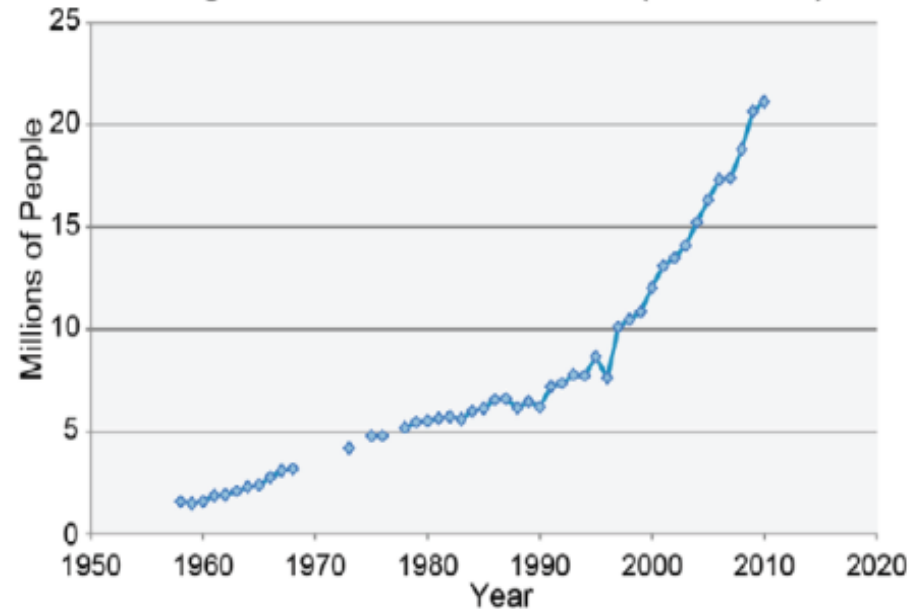
# Elements of Population Vulnerability to Climate Change

## Aging Population in the U.S.



**The proportion of Americans age 65 or older is growing at the fastest rate in a century. Older adults are more vulnerable to extreme heat, air pollution, and infectious illnesses**

## Diagnosed Diabetes in the U.S. (1958-2010)



**The number of Americans diagnosed with diabetes has grown sharply over 50 years. Those with diabetes are more vulnerable to heat-related illnesses**

# Key Message 3: Prevention Provides Protection

- ❑ Public health actions can do much to protect people from some of the impacts of climate change**
  - Especially preparedness and prevention
- ❑ Early action provides the largest health benefits**
- ❑ As threats increase, our ability to adapt to future changes may be limited**

# Diaspora after Natural Disaster: Population Displacement Following Hurricane Katrina

**Hurricane Katrina displaced more than 800,000 Louisiana residents, with evacuees found in every US state**

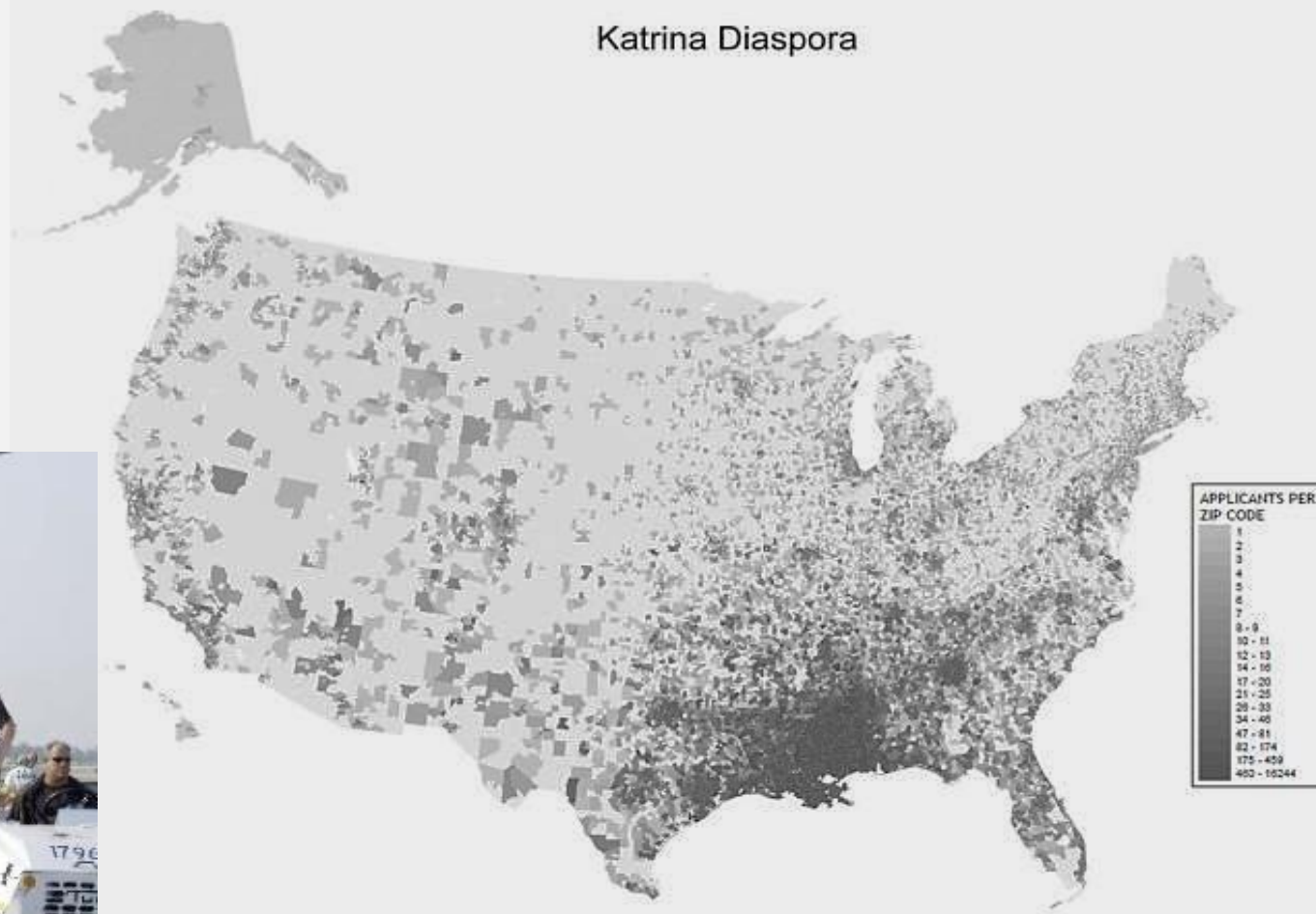


Figure 9.10, Health chapter NCA3  
Figure source: Kent 2006  
Photo: Michael Rieger/FEMA

# Key Message 4: Responses Have Multiple Benefits

- ❑ **Responding to climate change provides opportunities to improve human health and well-being across many sectors, including energy, agriculture, and transportation**
- ❑ **Many of these response strategies offer a variety of benefits, protecting people while combating climate change and providing other societal benefits**

# Climate Change Preparedness Benefits Health Today and Tomorrow

**Reducing fossil fuel use means:**

***Substantial immediate health benefits***

- In 11 upper Midwest cities, replacing 50% of short car trips with bicycling and the other 50% with public transit or walking avoids 1,300 deaths and \$8 billion in health costs annually
- More healthy outdoor exercise improves fitness and health

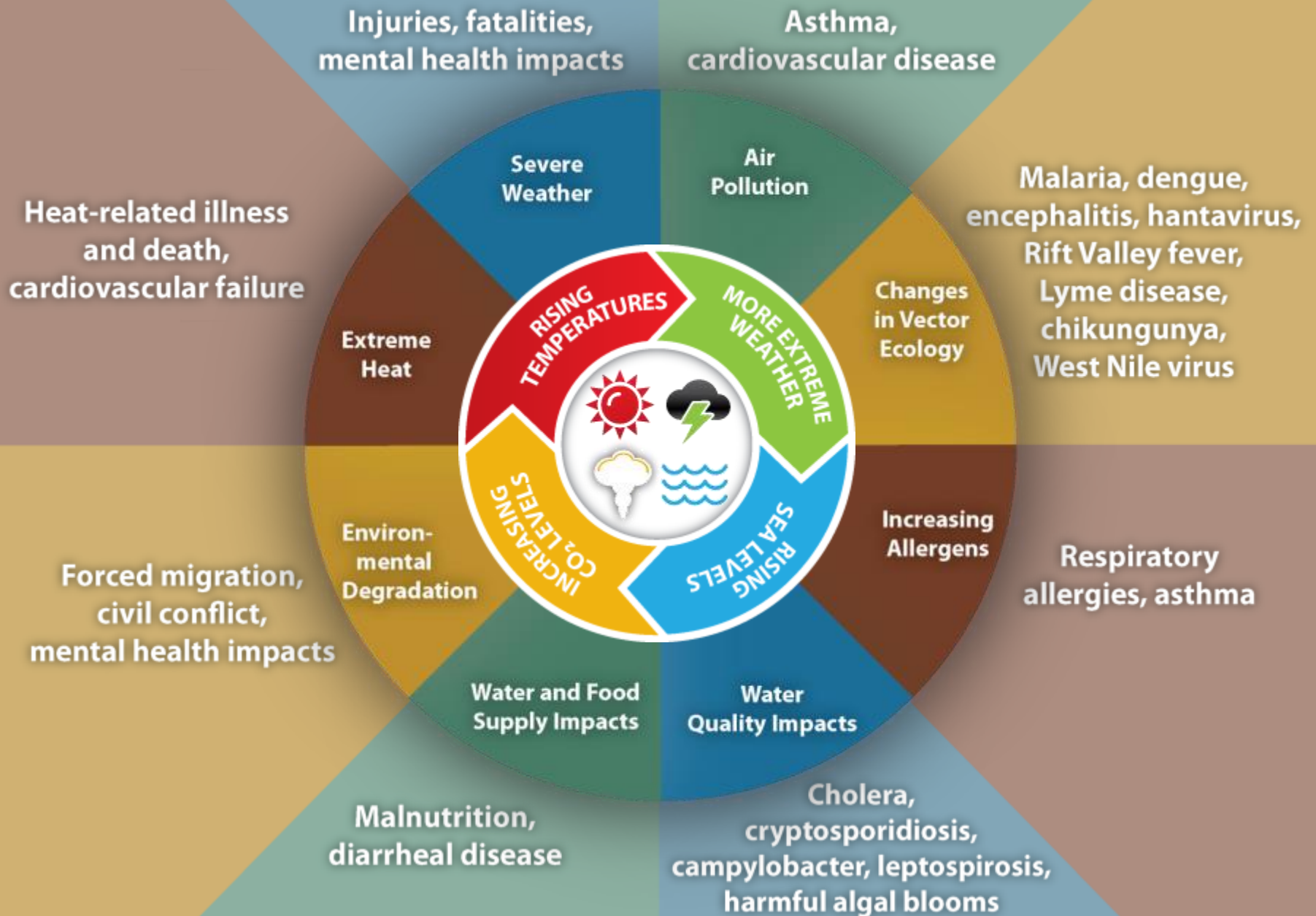
***Longer-term climate-health benefits***

- Include reduced risks of waterborne illnesses and beach closures in the Great Lakes
- Otherwise, projected to increase



From Grabow et al. (2012); Patz et al. (2008)  
Human Health chapter (ch.9, pp. 232 and 226), NCA3

# Impact of Climate Change on Human Health





# Third National Climate Assessment

## Climate Change Impacts in the United States

<http://nca2014.globalchange.gov>

#NCA2014



[facebook.com/usgcrp](https://www.facebook.com/usgcrp)



[@usgcrp](https://twitter.com/usgcrp)

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# How Climate Influences the Infectious Disease Landscape



**C. Ben Beard, MS, PhD**

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*Chief, Bacterial Diseases Branch*

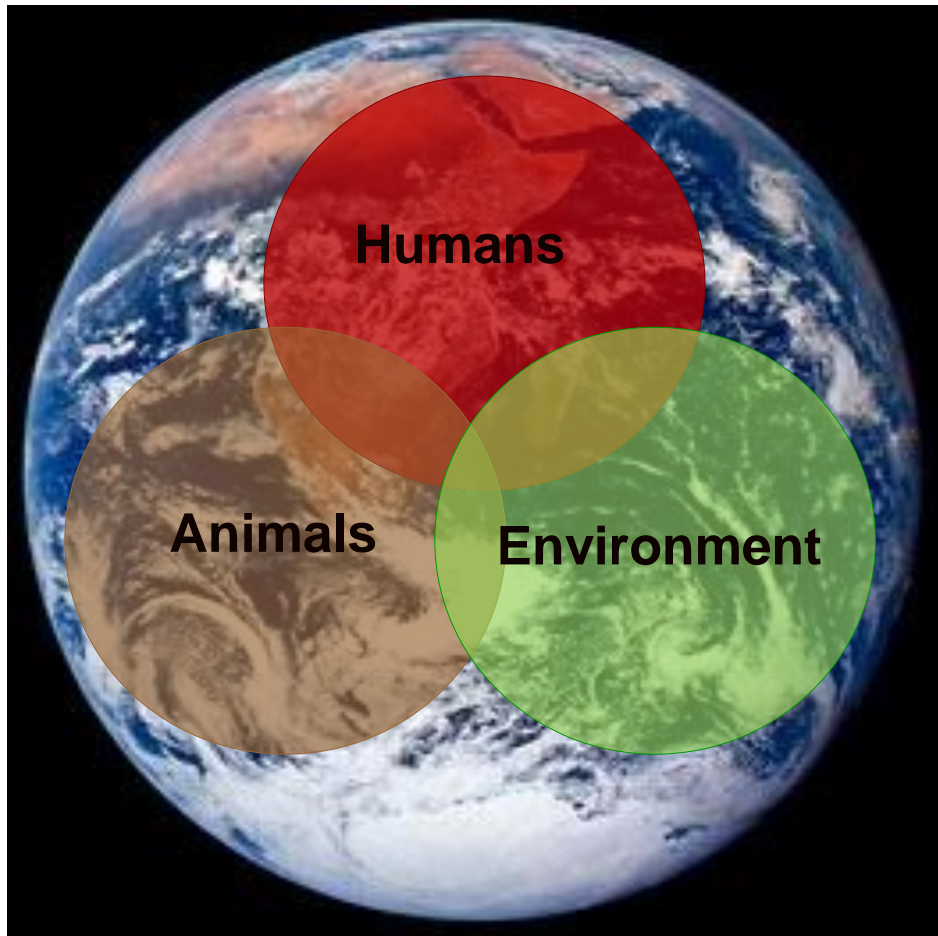
*Division of Vector-Borne Diseases*

National Center for Emerging and Zoonotic Infectious Diseases



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# Emerging Diseases Seen Through a “One Health” Lens



**One Health:**  
the collaborative effort of  
multiple disciplines —  
working locally,  
nationally, and globally —  
to attain optimal health  
for people, animals, and  
the environment

# Climate, Weather, and Infectious Diseases: The Big Picture

- ❑ **Changes in climate lead to changes in the environment, which result in changes in the incidence and distribution of diseases with environmental linkages**
- ❑ **Climate affects the distribution and abundance of pathogens and the vectors that carry them (e.g., ticks, mosquitoes) and their animal hosts**

# Climate, Weather, and Infectious Diseases: The Big Picture

- ❑ **Climatic variables (temperature and rainfall) affect disease transmission by impacting the replication, interaction, and survival of disease agents in animals, disease vectors, and the environment**
- ❑ **Climatic perturbations such as severe storms, droughts, and ENSO affect disease occurrence patterns and drive disease outbreaks**
  - ENSO (El Niño Southern Oscillation) describes both warm (El Niño) and cool (La Niña) ocean-atmosphere events that begin in the tropical Pacific Ocean

Luber, G., et al. 2014: Ch. 9: Human Health. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 220-256

Gage, K. L., T. R. Burkot, R. J. Eisen, and E. B. Hayes. American Journal of Preventive Medicine, 35, 436-450

# Types of Climate-sensitive Infectious Diseases

## ❑ Zoonotic

- Diseases that can be spread from animals to humans

## ❑ Vector-borne

- Diseases that are transmitted to humans through carriers (vectors) such as mosquitoes or ticks and are usually harbored in wild animals

## ❑ Waterborne

## ❑ Foodborne

## ❑ Soil and dust associated



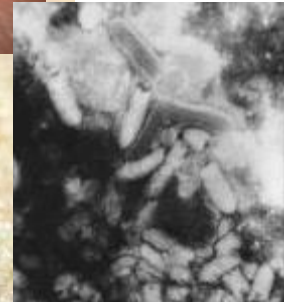
# Selected Infectious Diseases Potentially Affected by Climate Change

## □ Vector-borne and Zoonotic

- West Nile virus infection
- Lyme disease
- Rabies
- Dengue
- Malaria
- Chagas disease

## □ Environmentally-associated

- *E. coli* O157H7 infection
- Cholera
- Leptospirosis
- Vibriosis
- Valley fever
- Primary amoebic meningoencephalitis



# Vector-borne Disease Case Studies



**West Nile virus  
infection**

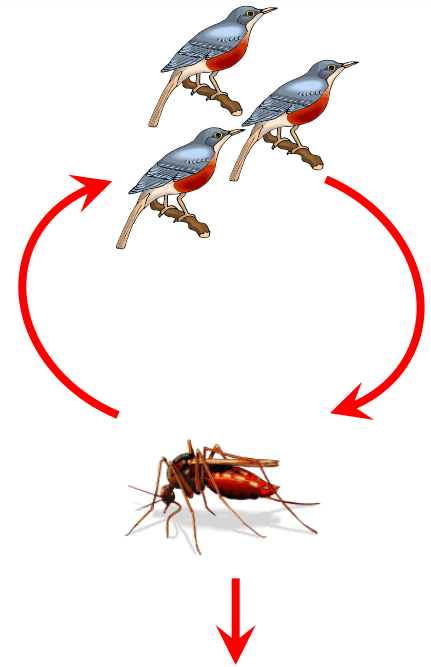


**Lyme disease**



# West Nile Virus: Biology, Life Cycle, and Human Disease

- ❑ Member of the *Flavivirus* genus in the JE virus subcomplex
- ❑ Transmitted primarily by *Culex* species mosquitoes
- ❑ Amplified by birds
- ❑ Humans and other mammals are “dead end” hosts
  - Not essential for pathogen life cycle
- ❑ **Clinical syndromes:**
  - West Nile fever (about 25% of cases)
  - Neuroinvasive disease (<1% of infections)



# Temperature, Precipitation, and West Nile Virus (WNV) Transmission

- ❑ **Temperature has a significant effect on mosquito life cycle and rate of viral replication**
  - Milder winters
  - Earlier onset of spring
  - Warmer summers
- ❑ **Precipitation also has a significant effect, but the relationship is more complicated and varies regionally**
  - The mosquito vectors for WNV vary in the eastern and western US
  - Rainfall can have different effects on the breeding habitat of these different vector species
  - The effects of rainfall vary depending on the region of the country

# West Nile Virus Outbreak of 2012

- ❑ **More than 5,600 human cases**
  - 2,873 neuroinvasive disease cases
  - 286 deaths
- ❑ **Largest outbreak since 2003**
- ❑ **Cases reported from all lower 48 states**
- ❑ **Focally-intense outbreak distribution**
  - ~ One-third of cases reported from Texas
  - ~ Half of Texas cases reported from the 4-county area around Dallas
- ❑ **Aerial spraying with insecticides was used around Dallas for the first time in almost 50 years**



# Factors Associated with the West Nile Virus (WNV) Outbreak of 2012

- ❑ **High level of WNV activity in the U.S. in 2012 was likely influenced by**
  - Mild winter in 2011 - 2012
  - Early spring
  - Hot summer
- ❑ **Long growing season combined with hot summer resulted in increased mosquito reproductive cycles and accelerated virus replication, facilitating WNV amplification and transmission to humans**

# Lyme Disease: Biology, Life Cycle, and Human Disease

- ❑ Caused by *Borrelia burgdorferi*
- ❑ Transmitted by *Ixodes* species ticks
- ❑ Reservoirs for the spirochete include small mammals (field mice, squirrels, chipmunks, etc.) and birds
- ❑ Hosts for the tick include
  - Small mammals (larvae and nymphs)
  - Deer and other large mammals (adults)
- ❑ Human illness can range from a fever, fatigue, and rash to carditis, facial palsy, and arthritis later in illness



# Climate, Weather, and Lyme Disease

- ❑ **Climate (primarily minimum temperature) defines the limit of northern distribution**
- ❑ **Warmer temperatures may increase the reproductive capacity of ticks, leading to larger populations and greater risk for disease transmission to humans**
- ❑ **Higher moisture levels allow ticks to survive in warmer environments**
- ❑ **Temperature and moisture affect the feeding behavior of ticks (“questing”)**
- ❑ **Temperature (measured by cumulative growing degree days) affects seasonality of disease**

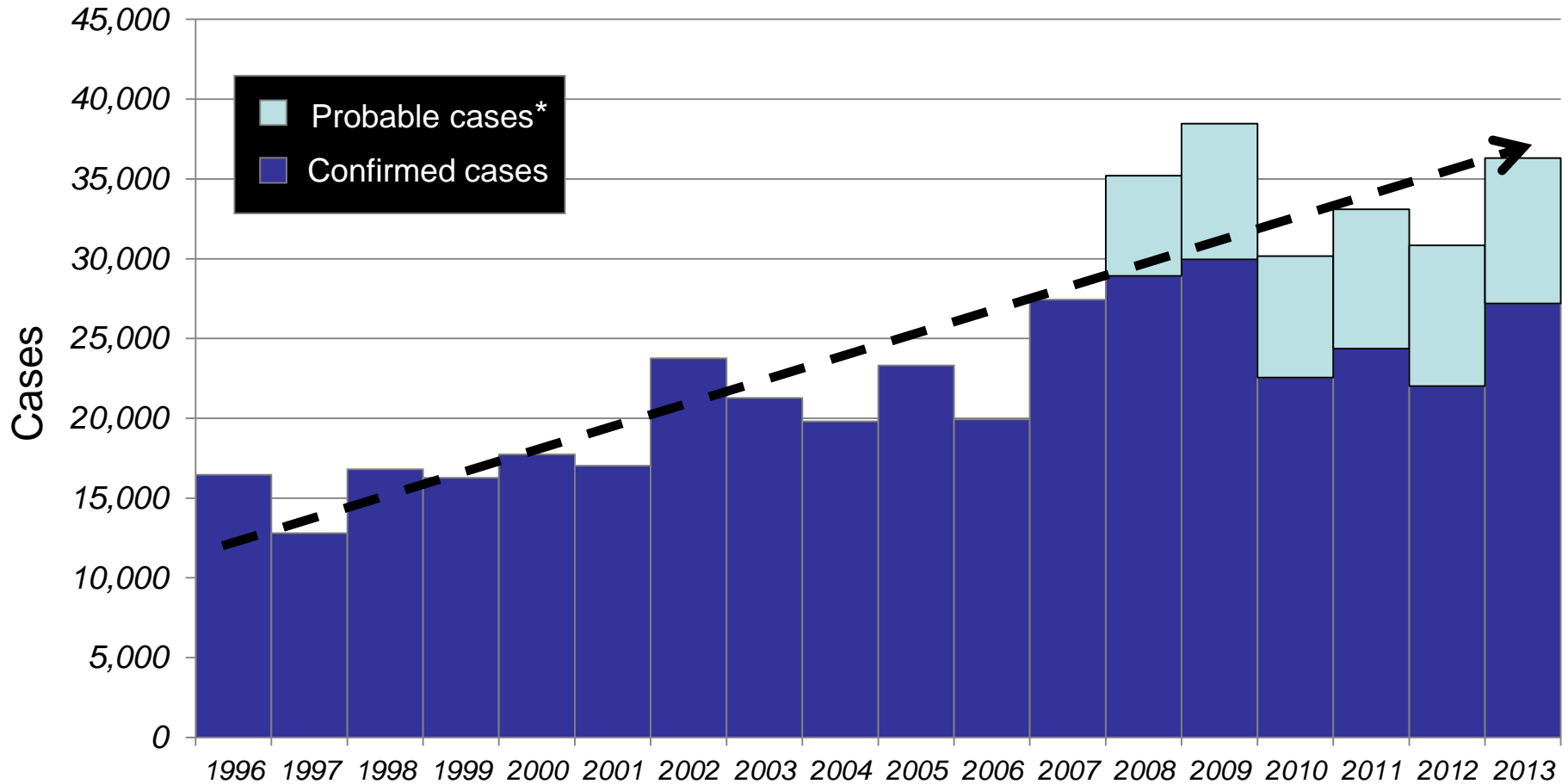
Brownstein, J. S., T. R. Holford, and D. Fish. 2003. *Environ Health Persp* 111: 1152-1157

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

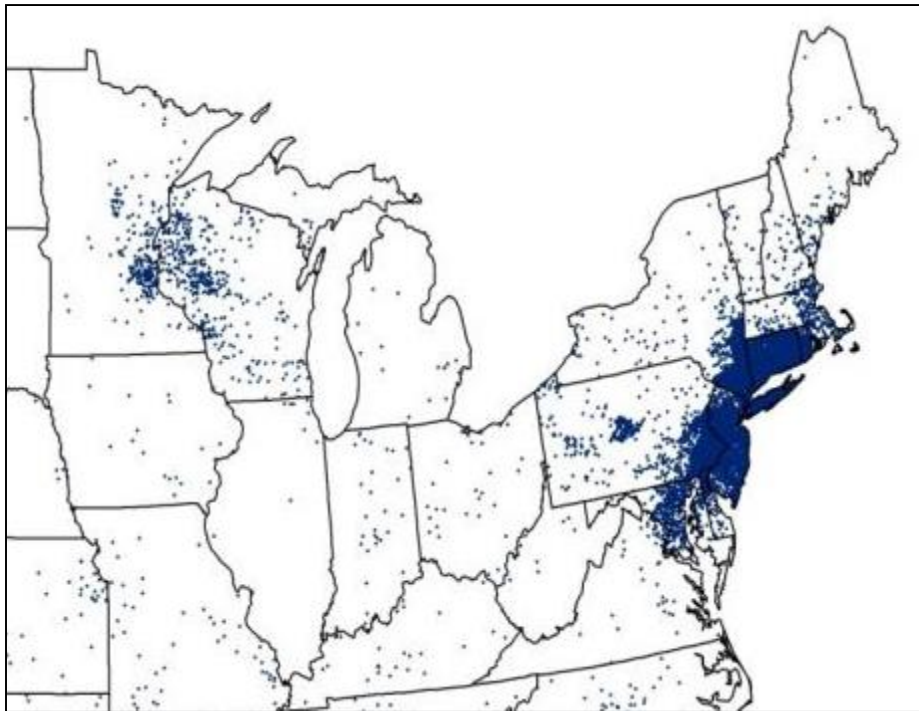
Moore, S. M., R. J. Eisen, A. Monaghan, and P. Mead. 2014. *Am J Trop Med Hyg* 90: 486-496

# Reported Cases of Lyme Disease United States 1996 - 2013

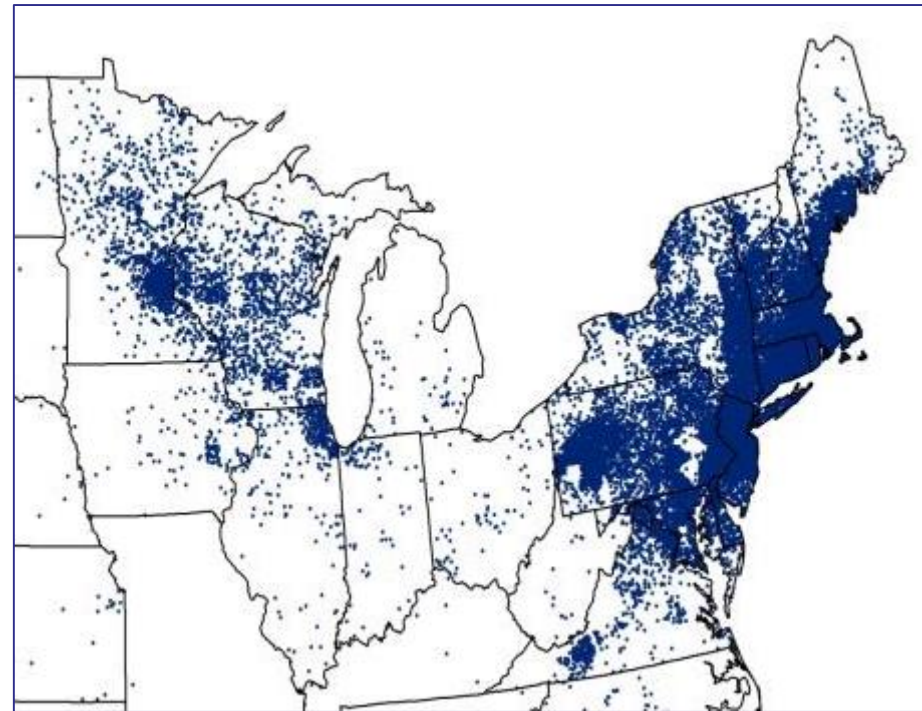


\*National Surveillance case definition revised in 2008 to include probable cases;  
details at [www.cdc.gov/ncphi/diss/nndss/casedef/lyme\\_disease\\_2008.htm](http://www.cdc.gov/ncphi/diss/nndss/casedef/lyme_disease_2008.htm)

# Lyme Disease US Case Distribution: 18-year Trend



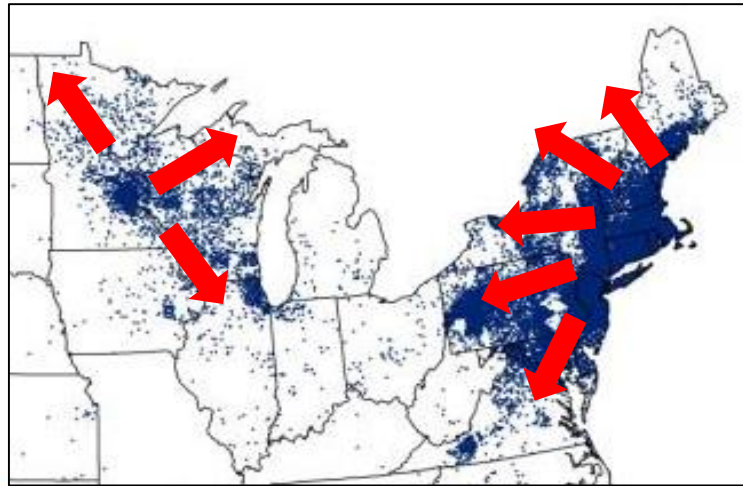
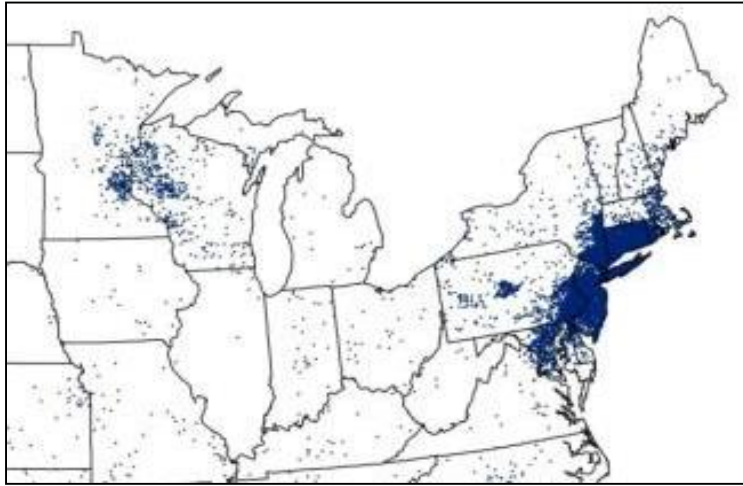
1996



2013



# Climate, Weather, and Lyme Disease: Results from Modeling



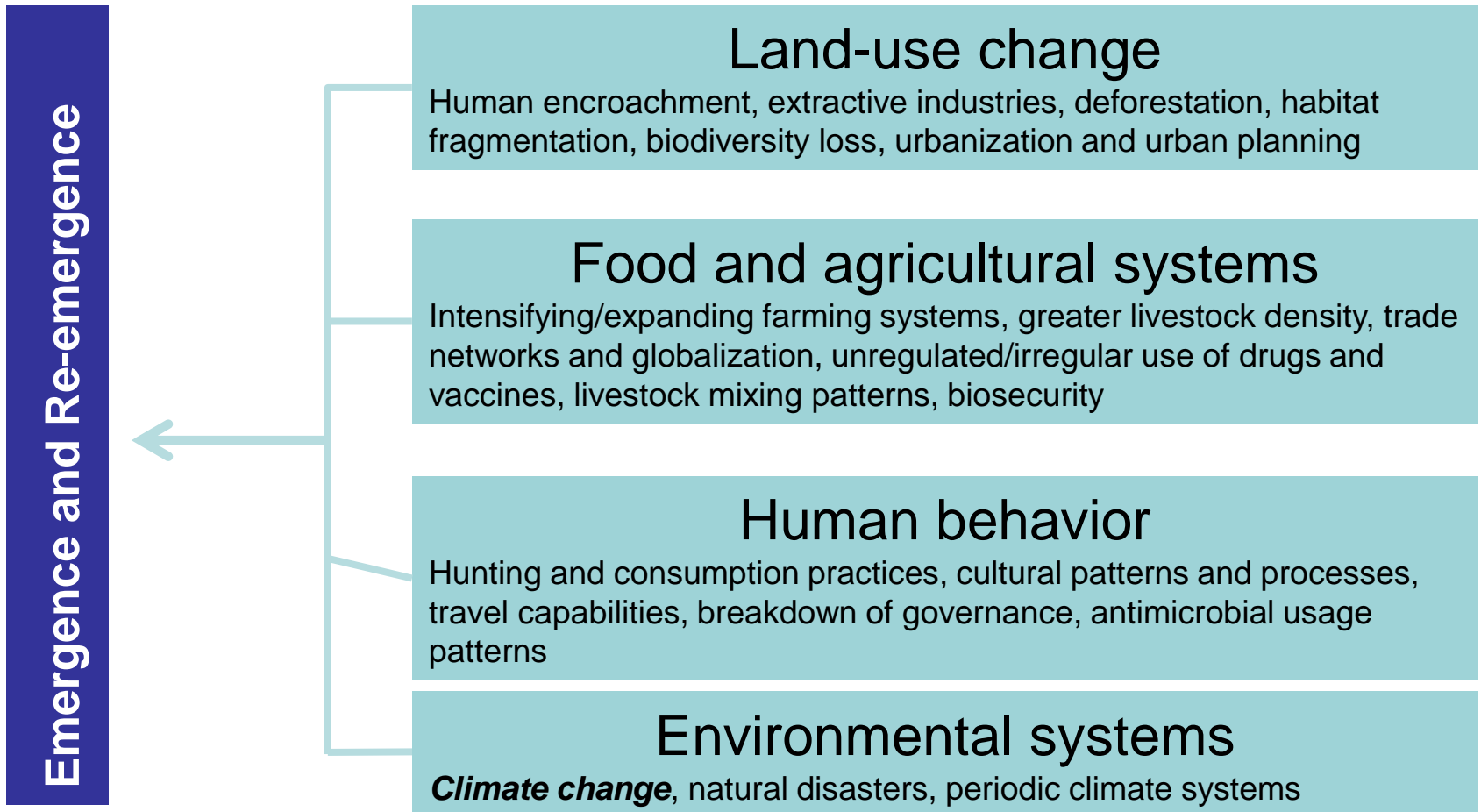
Climate warming may have co-driven Lyme disease emergence in northeastern North America and in the future may drive substantial disease spread into new geographic regions and increase tick-borne disease risk where climate is currently suitable.

Adapted from: Ogden NH et al. 2014

Map source: [www.cdc.gov/lyme/stats/maps/interactiveMaps.html](http://www.cdc.gov/lyme/stats/maps/interactiveMaps.html)

Ogden NH, Radojevic M, Wu X, Duvvuri VR, Leighton PA, Wu J. Environ Health Perspect. 2014 Jun;122(6):631-8.

# Reasons Diseases Emerge at the Human-Animal-Environment Interface



# Minimizing Adverse Health Effects of Climate-sensitive Infectious Diseases

## ❑ Public health surveillance

- Establish baseline levels of disease occurrence
- Track trends and monitor changes in geographic range of vectors and diseases

## ❑ Preparedness

- Maintain capacity for detection and response
- Develop decision-support tools

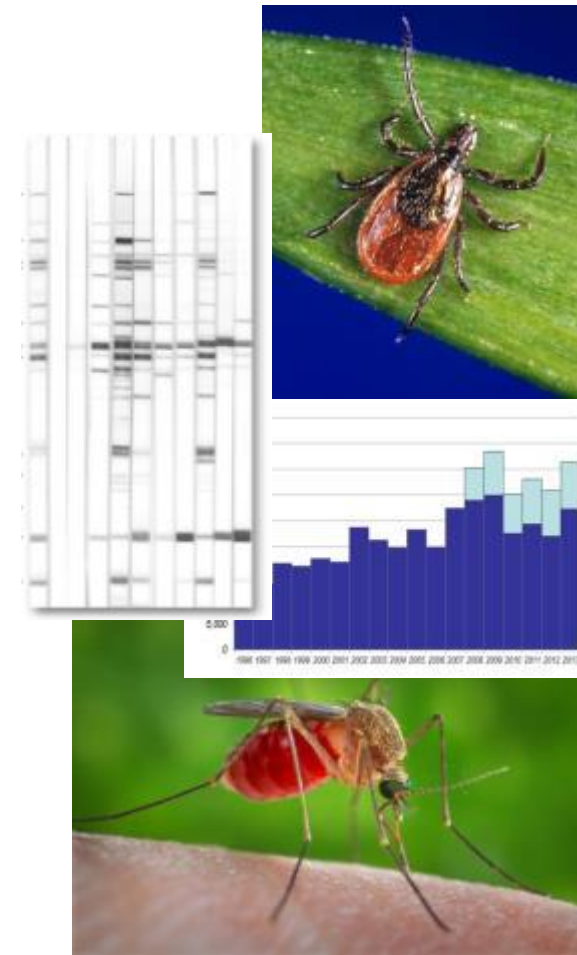
## ❑ Research

- Develop predictive models for changes in distribution, risk of disease introductions
- Identify cost-effective prevention methods



# Examples of Vector-borne Disease Prevention, Detection, and Response

- ❑ Vaccines for prevention of diseases like Lyme disease and West Nile virus infection
- ❑ Improved diagnostic tests that enhance our capacity for early and accurate diagnosis, treatment, and response
- ❑ Better information on disease burden and cost savings associated with specific prevention tools



# Building Resiliency to Climate Change: Helping Cities and States Respond



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National Center for Environmental Health

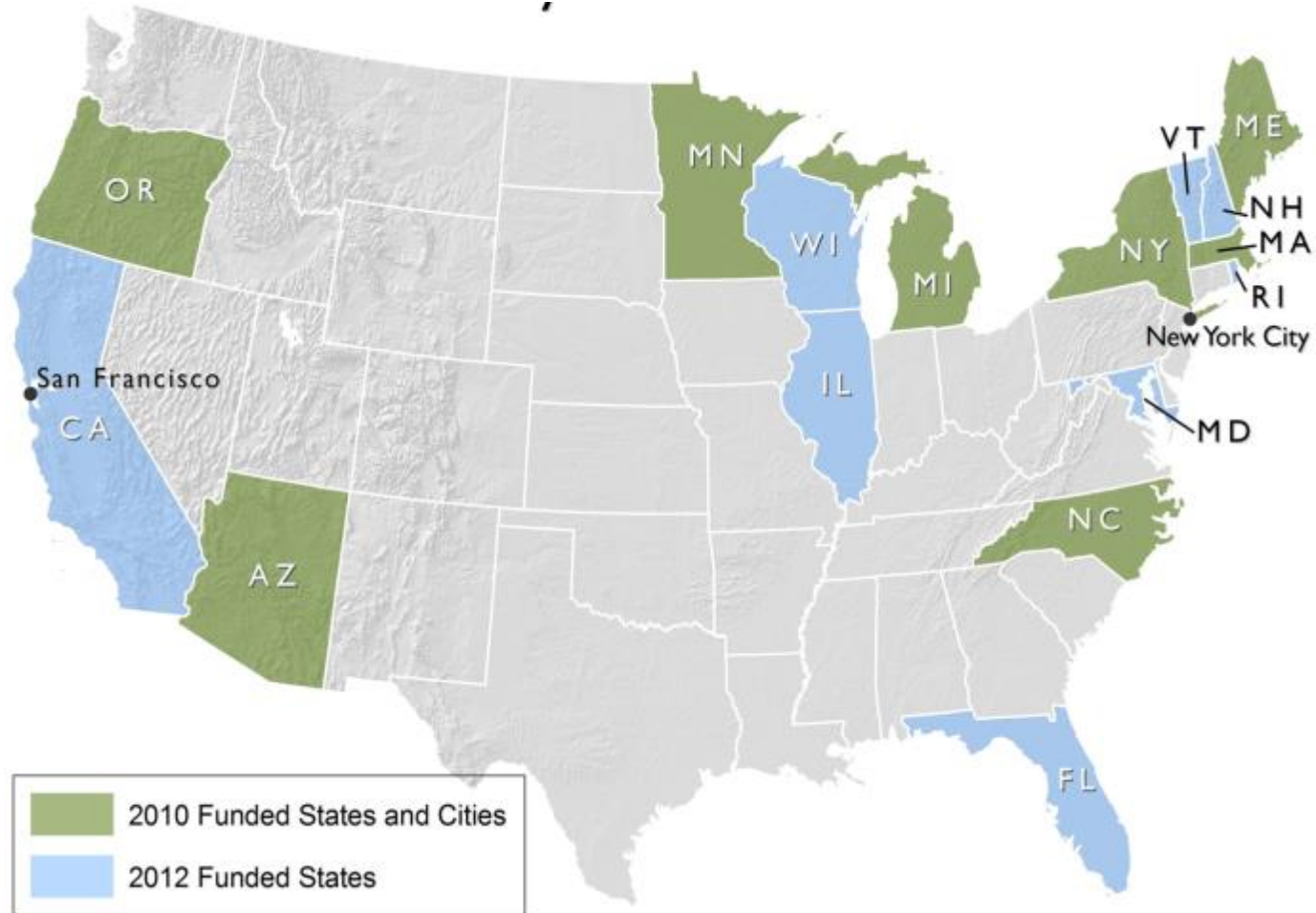
# Climate and Health Program at CDC

- ❑ **Established in 2009**
- ❑ **The only federal investment in building the climate change capabilities of health departments**
- ❑ **Helps states and cities prepare for health challenges of climate change by**
  - Providing scientific guidance
  - Developing decision support tools
  - Ensuring public health concerns are considered in climate change adaptation and mitigation strategies

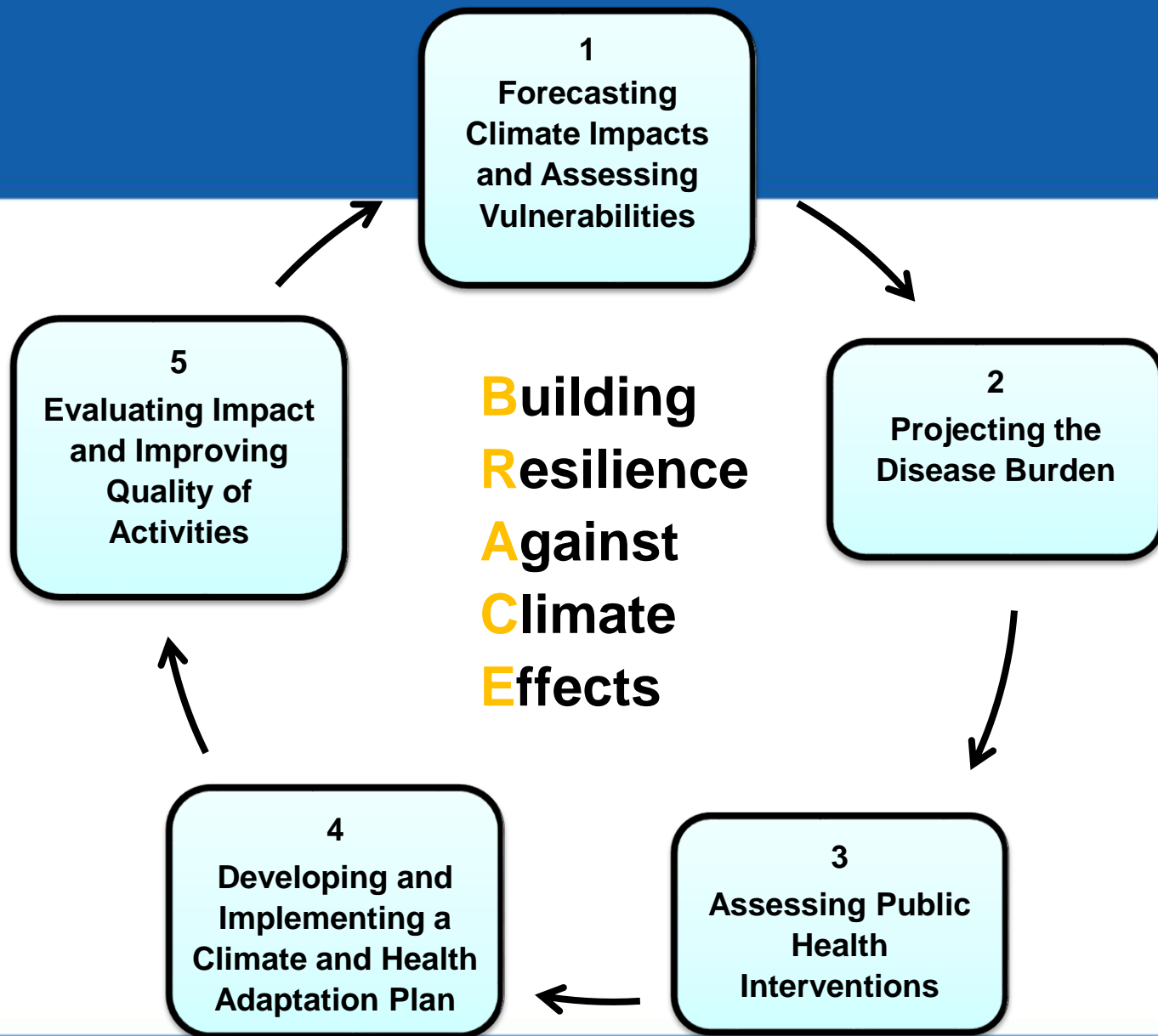
# Climate-Ready States and Cities Initiative

- ❑ **Effort to enhance capacity of state and local health agencies to deal with health challenges associated with climate change**
- ❑ **Accomplished by**
  - Funding 18 state and local health departments
  - Providing framework and tools for planning, implementing, and evaluating climate adaptation strategies
    - Tools to identify populations and places vulnerable to climate impacts
    - Materials to help communicate climate and health issues to public health partners (e.g., extreme heat tool kit)  
(Available at [www.cdc.gov/extremeheat/materials.html](http://www.cdc.gov/extremeheat/materials.html))

# CRSCI Grantees Addressing Climate Change Challenges to Public Health







# Success Stories: New York City and Heat Warnings

## ❑ Problem

- Magnitude and intensity of heat waves likely to increase in New York City in the future

## ❑ Action

- With CDC funding and support, the New York City Department of Health and Mental Hygiene investigated sensitivity and effectiveness of its extreme heat warning system
- Collaboration helped to better understand
  - Historical death and hospitalization data
  - Future temperature and humidity projections
  - Urban heat island interactions with heat vulnerability

# Success Stories: New York City and Heat Warnings

## ❑ Outcome

- Setting a lower threshold for a more sensitive and tailored heat-warning system

## ❑ Impact

- Heat warnings and advisories now more protective for New Yorkers
- Methodology being used by other jurisdictions to similarly tailor heat messaging and advisories to local conditions, resulting in lower heat thresholds for public health actions

# Success Stories: North Carolina and Storm Surge Forecasting

## □ Problem

- Storm surge associated with coastal storms can cause failure of drinking and wastewater infrastructure in coastal communities, leading to waterborne disease outbreaks



**Flooded wastewater treatment  
plant in Goldsboro, NC (1999)**

# Success Stories: North Carolina and Storm Surge Forecasting

## □ Action

- North Carolina Department of Health and Human Services identified critical drinking and wastewater infrastructure in coastal communities
- Collaboration with local water authorities enabled health officials to use climate change models to estimate coastal flooding
- Health officials used estimates of 0.5, 1, and 2 meter storm surge to map at-risk drinking water and wastewater infrastructure

## □ Outcome

- Findings inform both preparedness planning for existing facilities and decisions on sites for future facilities

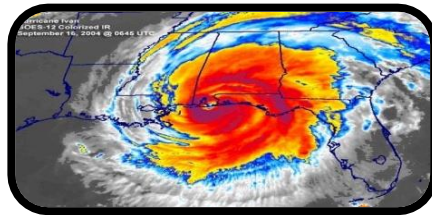
# Public Health Efforts to Prepare for and Respond to Health Effects of Climate Change

## □ **Climate-Ready States and Cities Initiative**

- Partnering with state and city health departments across multiple US regions
- Providing scientific, communications, and resource support

## □ **Building Resiliency Against Climate Effects (BRACE)**

- Efforts to respond to location-specific climate-related threats
- Better preparation for or prevention of environmental hazards caused by extreme temperatures, excess precipitation, or natural disasters



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# Impact of Climate Change on Human Health

