Public Health Heats Up:

The Impacts of Climate Disruption

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S.C. flood is 6th 1,000-year rain since 2010

The best iPhone deser the be netwo

Running dry: How the drought is forging a new California

California is living through a slow-motion natural disaster, a four-year drought that is combining with record heat to challenge the state in unprecedented ways.

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."

"Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century."

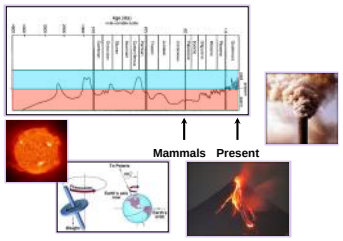
- Intergovernmental Panel on Climate Change
2014 Synthesis Report Summary for Policymakers

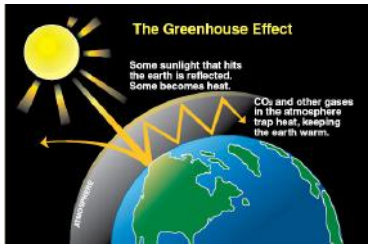
The Report:
- 1 scoping meeting to outline 30 chapters
- 217 author nominations representing 92 nationalities
- 242 lead authors and 66 review editors from 70 countries
- 436 contributing authors from 54 countries
- Over 12,000 scientific references cited

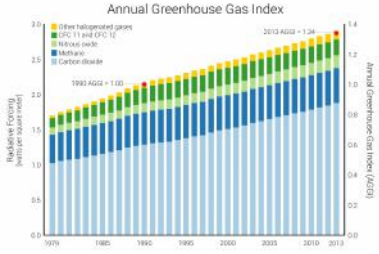
Total Reviews:
- 50,492 comments
- 1729 expert reviewers from 84 countries
- 49 governments

The WGII Approval Session
- 25-29 March 2014, Yokohama, Japan
- The Summary for Policymakers was approved line-by-line and accepted by the Panel, which has 195 member Governments

Natural Earth Cycles and Wobbles

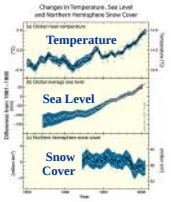




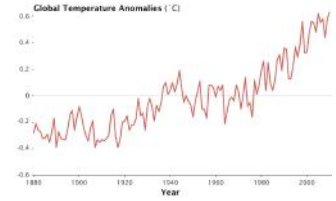


Climate Change is Happening Now

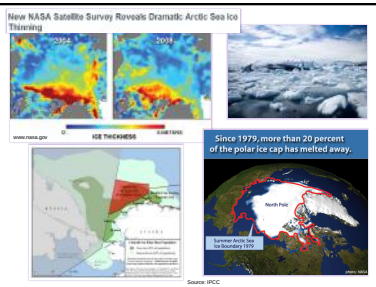
- Warming is unequivocal
- Physical and biological systems on all continents and oceans are already affected by climate changes
- Overall the earth has warmed 0.85°C from 1880-2012
- Arctic sea ice is disappearing at a rate of up to 50,000 km^2 per year
- Antarctic ice sheets are losing 159 billion tons of ice each year



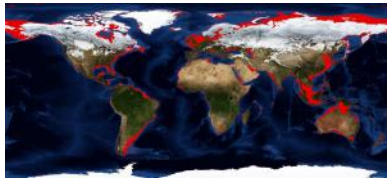
IPCC 2007
Health and Climate Change: Policy Responses to Protect Public Health. 2015 *The Lancet*



Nasa – Projected U.S. Temperature Changes by 2100
https://www.youtube.com/watch?v=39cBqY1sszY#action=share



Global sea level has risen by about 8 inches since reliable record keeping began in 1880. It is projected to rise another 1 - 4 feet by 2100.

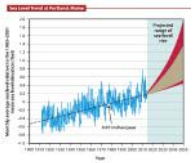


Source: http://nca2014.globalchange.gov/report/our-changing-climate/sea-level-rise

Coastal States at Risk from Global Sea Level Rise

People in states with low-lying coastlines have been subject to severe flooding and damage from coastal storms in recent years. Although all coastal states are vulnerable, Florida, Louisiana, New York, and California have the most residents living on land less than 3.3 feet above high tide. Depending on our future emissions—and the resulting ocean warming and land ice loss—global average sea level could rise to the 3.3-foot mark within this century.

Rising Sea Levels in Maine



Salt Marsh disappearance

Beach erosion

Inland migration of flood zones

Rising flood insurance rates

Newsweek: International Editions

Frogs: Global Warming's First Victims

Changes in climate have been associated with:

- Population declines in Costa Rica
- Breeding phenology in Great Britain
- Physiological changes in female toads, leading to increased female mortality rates and decreased fecundity in survivors

- Widespread amphibian extinctions
- Temperatures at many highland localities shifting towards the growth optimum of fatal fungus, chytrid *Batrachochytrium dendrobatidis*
- Unusual climatic conditions can alter development and increase frog susceptibility to various pathogens.
- Environmental stressors that can cause declines include loss of habitat, disease, pollutants, climate change

Amplification of warming in Arctic has global implications for bird populations

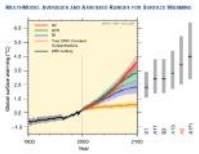
- Advancement in species' phenology over past 30-60 years
  - Migration: 1.3-4.4 days earlier per decade
  - Breeding: 1.9-4.8 days earlier per decade
- Poleward shifts of range margins
  - 18.9 km average range movement northward over 20-year period

Alterations in Habitat and Food Availability

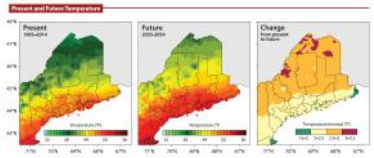
- Increased competition for nest sites for those species that do not migrate early
- Mismatch between the peak in insect availability and the peak food demands

A 2°C increase in global temperature is inevitable even if we take dramatic action

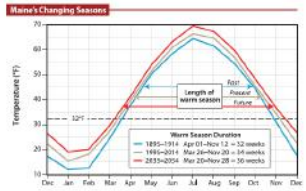
Even if countries meet their current non-binding pledges to reduce carbon emission, we will still be on course to reach a 3°C average temperature increase by the end of this century.



Temperature Change in Maine



Maine's Lengthening Summer



"Warm Season"– average daily temperature >32F

Climate Change Affects Human Health in Two Principle Ways

1. Changing the severity and frequency of health problems that are already affected by climate and weather factors

2. Creating unanticipated health problems or health threats in places where they have no previously occurred.

Climate Change and Health

Climate Drivers
- Increased temperatures
- Precipitation extremes
- Extreme weather events
- Sea level rise

Non-Climate Stressors
- Land-use change
- Ecosystem degradation
- Infrastructure condition
- Geography
- Agricultural production & livestock use

Social Determinants
- Age & gender
- Race & ethnicity
- Poverty
- Housing & infrastructure
- Education
- Discrimination
- Access to care & community health infrastructure

Exposure Pathways
- Extreme heat
- Poor air quality
- Reduced food & water quality
- Changes in infectious agents
- Population displacement

Health Outcomes

Heat-related Illness | Cardio-pulmonary Illness | Vector-borne Disease | Water-borne Disease | Food-borne Disease & Nutrition | Mental Health

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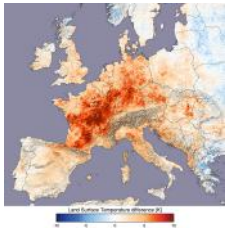
Heat-Related Death and Illness

- Hotter than normal or colder than normal days can compromise the body's ability to regulate temperature
- In the presence of extreme heat, loss of temperature control can result in heat cramps, heat exhaustion, heatstroke, hyperthermia, and worsening of already present chronic conditions.
- The elderly, children, people working outdoors, and economically disadvantaged groups are at an increased risk of death during a heat wave.
- Between the years 2030 and 2050, climate change is expected to cause an additional 38,000 deaths per year due to heat exposure in the elderly.

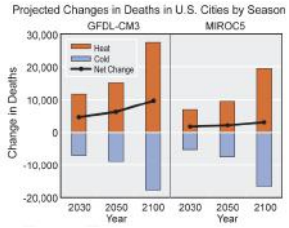
Source: WHO, http://www.who.int/mediacentre/factsheets/fs266/en/

European Heat Wave

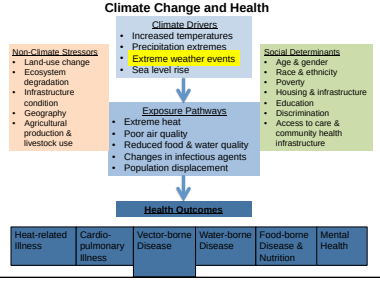
- The summer 2003 European heat wave caused more than 30,000 excess deaths.
- Hottest summer in Europe since 1500 AD.



Sources:
WHO,
http://www.who.int/mediacentre/factsheets/fs266/en/
Stott PA, Stone DA, & Allen MR. Human
Contribution to European Heatwave of 2003. Nature.
2004. 432; 610-614



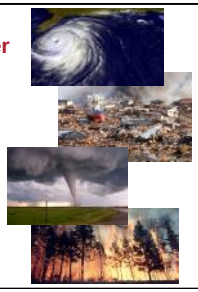
Climate Change and Health



Extreme Weather

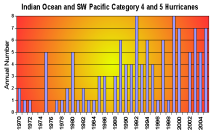
- Globally, the number of reported weather-related natural disasters has more than tripled since the 1960s.
- Every year, disasters result in over 60,000 deaths, mainly in developing countries.
- By the 2090s, climate change is expected to widen the area affected by drought, double the frequency of extreme droughts, and increase their average duration six-fold.
- Health Hazards associated with extreme weather events:
  - Death, injury, or disease
  - Negative effects on physical, mental, and social well-being
  - Exacerbation of existing medical conditions

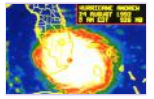
Source: WHO, http://www.who.int/mediacentre/factsheets/fs266/en/



Tropical Cyclones

↑ sea-surface temperatures → ↑ tropical cyclone intensity and ↑ height of storm surges

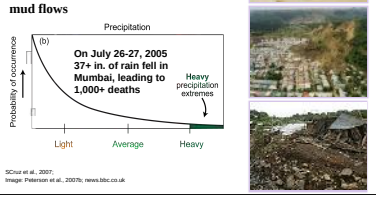




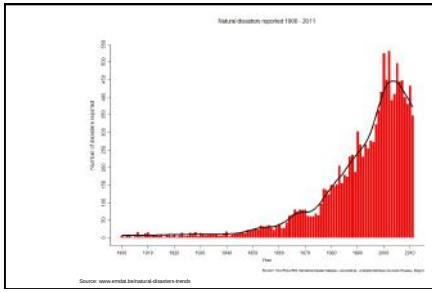
All, 1999
Images: NOAA.gov; www.weatherunderground.com

Extreme Precipitation Events

↑ **frequency of more intense rainfall → severe floods, landslides, and debris and mud flows**



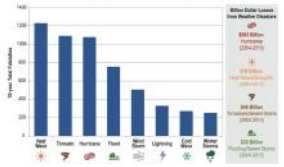
SCruz et al., 2007;
Image: Peterson et al., 2007b; news.bbc.co.uk



Source: www.emdat.be/natural-disasters-trends

Cost of Natural Disasters

In 2014, the United States spent $25 billion for the economic and insured losses incurred from natural disasters.



Source: http://www.nytimes.com/interactive/2015/09/08/us/hotspots-natural-disasters.html?_r=0
Image: NOAA, 2015

Climate Change and Health

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- Reduced food & water quality
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- Population displacement

Health Outcomes

Heat-related Illness	Cardio-pulmonary Illness	Vector-borne Disease	Water-borne Disease	Food-borne Disease & Nutrition	Mental Health

Climate Change Implication for Air Quality and Respiratory Illness

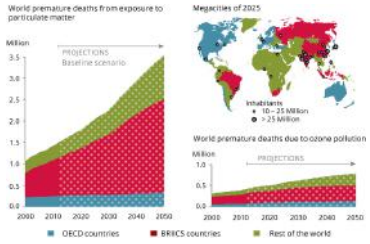
Modified weather patterns influence the level and location of outdoor air pollutants such as ground-level ozone and fine particulate matter

Droughts also tend to exacerbate respiratory illnesses through reduced air quality

- Soil drying
- Loss of vegetation
- Airborne particulate matter
- Dust storms
- Wildfires

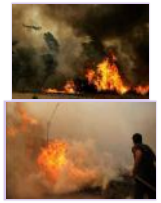
Mississippi River. St. Louis, Missouri, 2012

Source: WHO. http://www.who.int/mediacentre/factsheets/fs290/en/



Direct Effects of Hydrologic Extremes

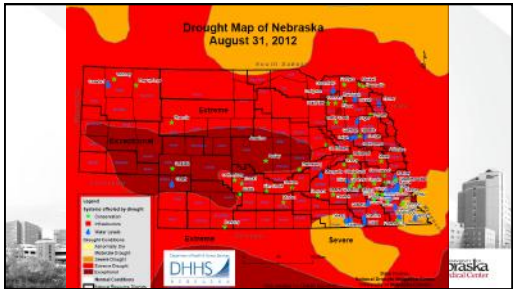
↑ drier climates → forest fires and smoke



Vulnerable Populations:

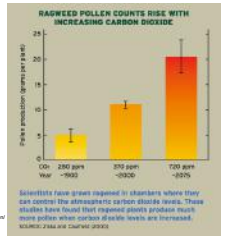
- Young Children
- Elderly
- Pregnant Women
- People with pre-existing respiratory and cardiac diseases

Ziska et al., *J Allerg Clin Immunol* 2003;111:290-95
Image: www.abcnews.net/au



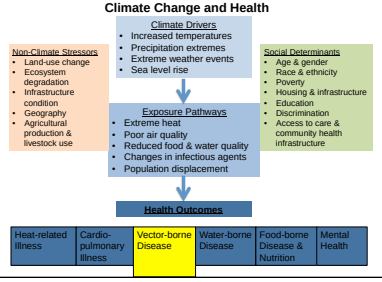
Greater Pollen Counts

- Pollen and other aeroallergen levels are higher in extreme heat.
- Longer growing seasons under a warmer climate allow for bigger ragweed plants that produce more pollen later into the fall.
- More airborne allergens could mean more asthma attacks.
- Asthma affects around 300 million people worldwide



Sources:
WHO: http://www.who.int/mediacentre/factsheets/fs266/en/
National Wildlife Foundation: http://www.nwf.org/pdf/Reports/NWF_AllergenFinal.pdf

Climate Change and Health



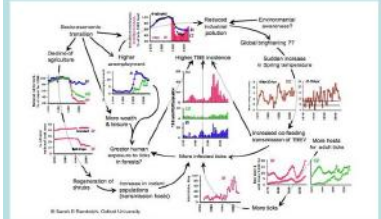
The Impact of Climatic Factors on Vectorborne Zoonotic Diseases

- Climatic factors (e.g., temperature, moisture) affect the distribution and abundance of vectors and vector-borne pathogens
- Climatic factors affect disease transmission efficiency (vector competence)
- Climatic variables and perturbations can affect disease occurrence patterns

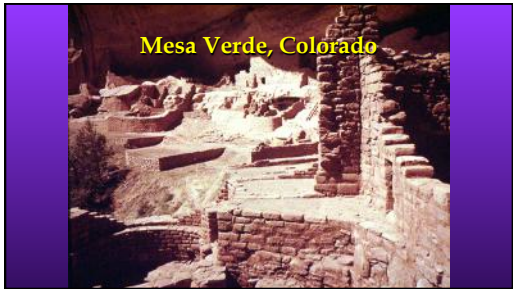
Climate Change
Infectious Disease Consequences

Category	Examples	Rationale
Vector-Borne	Malaria, Dengue, WNV, RVF, TBE, Lyme	Vector Distribution
Water-Associated	Cholera, Crypto, Lepto	Flood Runoff, Water Temperature
Foodborne	Salmonella, E. coli	Sanitation Issues
Airborne	Q-Fever, Meningococcus	Higher Relative Humidity
Soil-Associated	Anthrax, Clostridia	Temp, RH, Moisture
Rodent-Borne	Lassa, Hantavirus	
Multistage Parasites	Fasciolasis	Intermediate Hosts

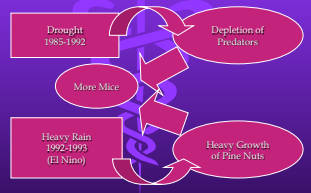
Vector-borne diseases



Emerging disease



Ecology of HPS



Droughts

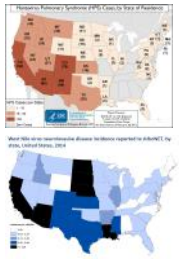
Reducing water quantity can reduce water quality from increased pollutant concentration, stagnation, and higher temperatures than can encourage pathogen growth.

Drought has also increased the incidence of West Nile virus disease.

- During droughts mosquitos find the remaining water sources and transmit the virus to other species

Droughts followed by periods of heavy rainfall have been associated with an increase in rodent populations

- Could potentially increase prevalence of hantavirus

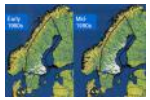


Current Effects of Climate on ID:
at least some EIDs are linked to climate change

- *Cryptococcus gattii*
- *Vibrio parahaemolyticus*
- Tick-borne Encephalitis
- Shortened respiratory syncytial virus (RSV) season in northern climates

***Vibro parahaemolyticus* in seafood**

***Cryptococcus gattii*, a tropical pathogen emerging in a temperate climate zone**



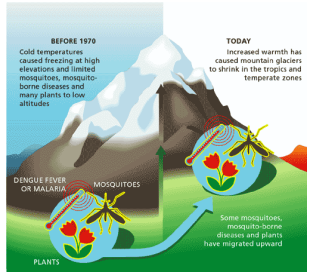
TBE, Sweden

Environ Health Perspect. 2000; 108(2): 119-23
The Lancet 2001; 358(9275):16

Changes in Lyme Disease Case Distribution, United States

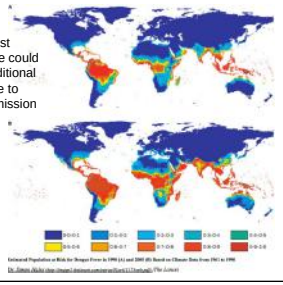
2001 **2013**

Source: CDC, http://www.cdc.gov/lyme/stats/index.html



Aedes in the USA

Studies suggest climate change could expose an additional 2 billion people to dengue transmission by 2080.



Source: WHO.

How does climate effect Malaria?

Plasmodium species grow faster at higher temperatures (optimal between 27-30°C).

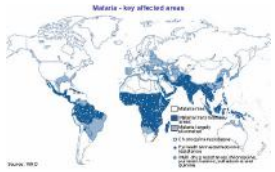
Vectorial capacity of mosquitoes increases as temperature increases (optimal temperature between 22-30°C).

Mosquito lifespan increases with higher temperatures

Females increase blood meal frequency at higher temperatures.

Aquatic life cycle of mosquitoes reduced from 20 to 7 days.

The Intergovernmental Panel on Climate Change (IPCC) predicts that the global population at risk for malaria will increase by 220-400 million in the next century.



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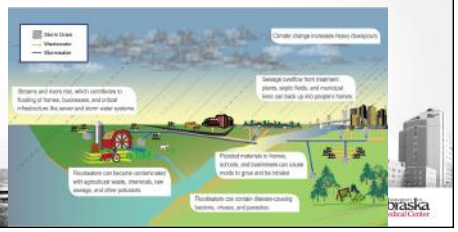
Hydrologic Extremes and Waterborne Disease

Milwaukee 1993:
- Cryptosporidiosis epidemic
- 405,000 cases, 54 deaths
- Preceded by heaviest rainfall in 50 years (Curriero et al., 2001)
- $31.7M in medical costs
- $64.6M in lost productivity

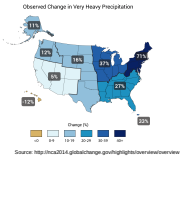
Corso et al., 2003

Heavy Downpours Are Increasing Exposure to Disease



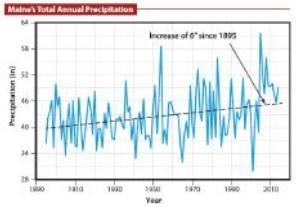
Intense Rainfall is Increasing in the Northeast

Increases the risk of failure of, or damage to, water infrastructure for drinking water, wastewater, and stormwater, thus increasing risk of exposure to water-related pathogens, chemicals, and algal toxins.

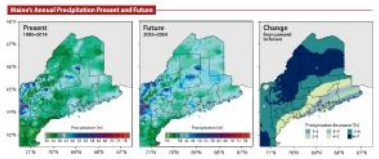


Source: http://nca2014.globalchange.gov/highlights/overview/overview

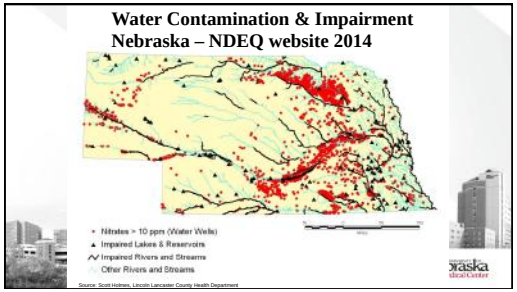
Precipitation in Maine



Precipitation in Maine



Water Contamination & Impairment Nebraska – NDEQ website 2014



Harmful Algal Blooms (Red Tides)

Enhanced by

- Increased water temps
- Nutrient runoff
- Upwelling events

Figure 2. Distribution of the CyanoHAB, *Cylindrospermopsis raciborskii*, in Florida (Williams 2001, Fristachi et al. 2007). *C. raciborskii*, which produces potent hepatotoxins (Table 2), was originally found only in tropical areas but has recently spread to cooler regions.

Elevated Sea Surface Temperatures

Elevated sea surface temperatures associated with climate change will increase human exposure to water contaminants in food.

Warmer water in Alaska from 1997-2004 was associated with an outbreak of *Vibro parahaemolyticus* in 2004.

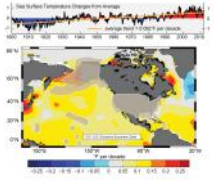
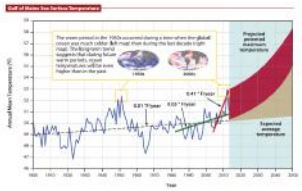
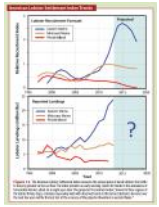


Image Source: http://nca2014.globalchange.gov/report/regions/oceans
Source: McLaughlin, J. A., A. DePaola, C. A. Bopp, K. A. et al, 2005. Outbreak of *Vibrio parahaemolyticus* gastroenteritis associated with Alaskan oysters. *The New England Journal of Medicine*

Gulf of Maine
Sea Surface Temperature Rise



Effects of Sea Changes



Unpredictable events

Decline in phytoplankton
-shrimp food

Shifting marine animal territories
-movement of lobster harvest

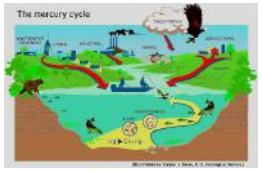
Influx on news species

Loss of other species

Bioaccumulation of Methylmercury

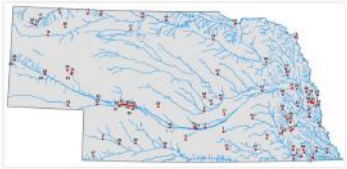
Elevated water temperatures may lead to higher concentrations of methylmercury (a form of mercury that can be absorbed into the bodies of animals, including humans)

Methylmercury exposure can affect child development, particularly if exposed in-utero



Sources:
1. Dijkstra, J. A., K. L. Buckman, D. Ward, D. W. Evans, M. Dionne, and C. Y. Chen. 2013: Experimental and natural warming elevates mercury concentrations in estuarine fish.
2. Gonzalez-Estecha, M., and Coauthors, 2014: [The effects of methylmercury on health in children and adults: national and international studies].

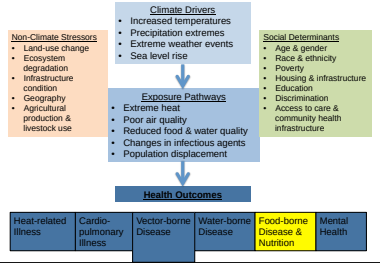
Nebraska Fish Consumption Advisories – 2013
Primarily Due to Mercury Contamination



92 Lakes and Streams in Nebraska

Source: Scott Holmes, Lincoln Lancaster County Health Department

Climate Change and Health



Rising Temperatures Can Decrease Food Safety

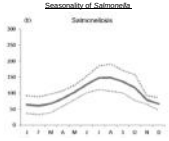
Rising temperatures and changes weather extremes is expected to intensify pathogen and toxin exposure, increasing the risk and incidence of foodborne illnesses.

Some pathogens thrive in warm, humid conditions
- *Salmonella*
- *Escherichia coli (E. coli)*
- *Campylobacter*

Foodborne illnesses peak in the summer
- Warmer weather
- Food preparation outdoors
- Leaving food outside at picnics and BBQs

Salmonella on raw chicken will double in number approximately every hour at 70°F, every 30 minutes at 80°F, and every 22 minutes at 90°F.

Seasonality of Salmonella

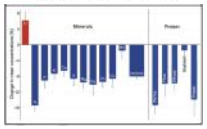


Sources:
1. Barancyl, J., and M. L. Tamplin, 2004: ComBase: a common database on microbial responses to food environments. *Journal of Food Protection*
2. Oscar, T., 2009: Predictive model for survival and growth of Salmonella Typhimurium DT104 on chicken skin during temperature abuse. *Journal of Food Protection*

Food Nutrition

- Increases in CO2 will likely increase carbohydrate content in food, while as the same time decreasing the protein and essential mineral content.
- "Hidden Hunger" is the sufficient or excessive intake of calories but insufficient intake of one or more micronutrients, such as vitamin A, iron, iodine, and zinc.
- Micronutrient deficiencies adversely affect metabolism, the immune system, cognitive development and maturation, and can be a factor in the prevalence of obesity.
- Aquaculture
  Climate change is altering fish distribution and productivity of marine and fresh water species

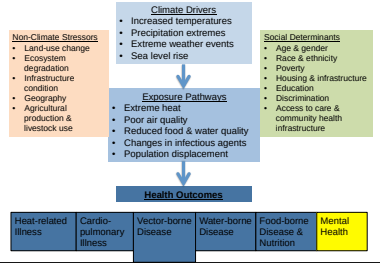
Effects of Carbon Dioxide on Protein and Minerals

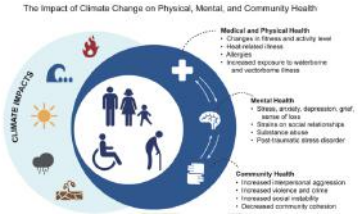


Pest Distribution

- Climate change will also alter the distribution of pests, parasites, and microbes, which will lead to increases in the use of pesticides
- Increased human exposure to chemical contaminants in the food chain.

Climate Change and Health





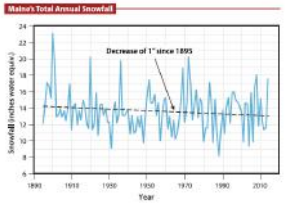
A 2°C Temperature Increase Can Make People Angrier

- Spikes in temperature and precipitation can increase the risk of personal violence and social upheaval
- While climate is not the sole or primary cause of violence, it undeniably exacerbates existing social and interpersonal tension in all societies, regardless of wealth or stability.

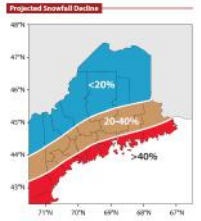
http://wattsupwiththat.com/2013/08/01/claire-2c-temperature-increase-will-make-people-angry/

The Heat Index in Maine

Snowfall Decline in Maine



Projected Snowfall Decline



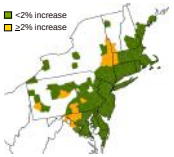
"Climate change is a problem which can no longer be left to future generations."

- Pope Francis

Public Health Response to Climate Change

- Enhanced surveillance
  - Human cases in previously disease-free areas
  - Introduction of new vectors, hosts, or pathogens
  - Changing transmission patterns recognition and response
  - Identify potential vulnerable populations
- Strengthen public health infrastructure to improve measures to reduce the spread of disease or disease vectors and hosts

Average annual increase in Lyme disease, selected U.S. counties, 1992-2006



*Counties reporting average of ≥5 cases annually

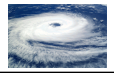
Public Health Response to Climate Change

- Modeling and long-term ecological and epidemiological research on influence of environmental changes on disease cycles
- Preparedness: Review, evaluate and prepare adaptive countermeasures (vaccines, therapeutic agents, insecticides, etc.)
- Training & Education: PH workforce

Public Health Response to Climate Change

- Encourage transition to cities that support and promote lifestyles that are healthy for the individual and for the planet.
- Adopt mechanisms to facilitate collaboration between Ministries of Health and other government departments, empowering health professionals and ensuring that health and climate considerations are thoroughly integrated in government wide strategies
- Expand access to renewable energy to low and middle income countries
- International agreement that supports countries in transitioning to a low-carbon economy

Source: Health and climate change: policy response to protect public health. 2015 *The Lancet*



Challenges

- Communicating uncertainty
- Climate change must be framed as a public health issue
- The costs of not taking action are high
- Linking meteorological science with health – "new demands on science and services"

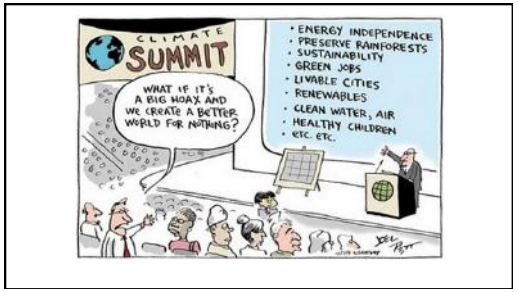
The Impact on Maine

More Rain
- Pine Needle Blight

More Intense Rain
- Lake & Stream Pollution
- Infrastructure Repair Costs

Less Snow, Longer Summer
- Less Winter Recreation
- Longer Crop Season
- Increase in Ticks
  - Lyme Disease

Earlier Spring
- Maple Syrup Production


CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.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