

*Climate Change and Human Health:
Risks and Responses*

2008 MAWVEC

**Joel D. Scheraga, Ph.D.
National Program Director
Global Change Research Program
Office of Research and Development**

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The polar bear might not be the only threatened species

“How it threatens your health”



HEALTH EFFECTS OF CLIMATE CHANGE

**CLIMATE
CHANGE**

*Temperature Rise*¹

*Sea level Rise*²

Hydrologic Extremes

¹ 3°C by yr. 2100

² 40 cm " "

IPCC estimates

**Urban Heat Island
Effect**

Heat Stress
Cardiorespiratory failure

**Air Pollution &
Aeroallergens**

Respiratory diseases, e.g.,
COPD & Asthma

Vector-borne Diseases

Malaria
Dengue
Encephalitis
Hantavirus
Rift Valley Fever

Water-borne Diseases

Cholera
Cyclospora
Cryptosporidiosis
Campylobacter
Leptospirosis

**Water resources & food
supply**

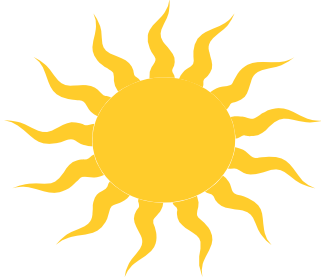
Malnutrition
Diarrhea
Toxic Red Tides

**Mental Health &
Environmental
Refugees**

Forced Migration
Overcrowding
Infectious diseases
Human Conflicts

Patz, 1998

Climate Change and Human Health in Minnesota



**Heat-related
mortality & morbidity**



**Changes in
air quality**



**Water-borne
diseases**



**Airborne
allergens**

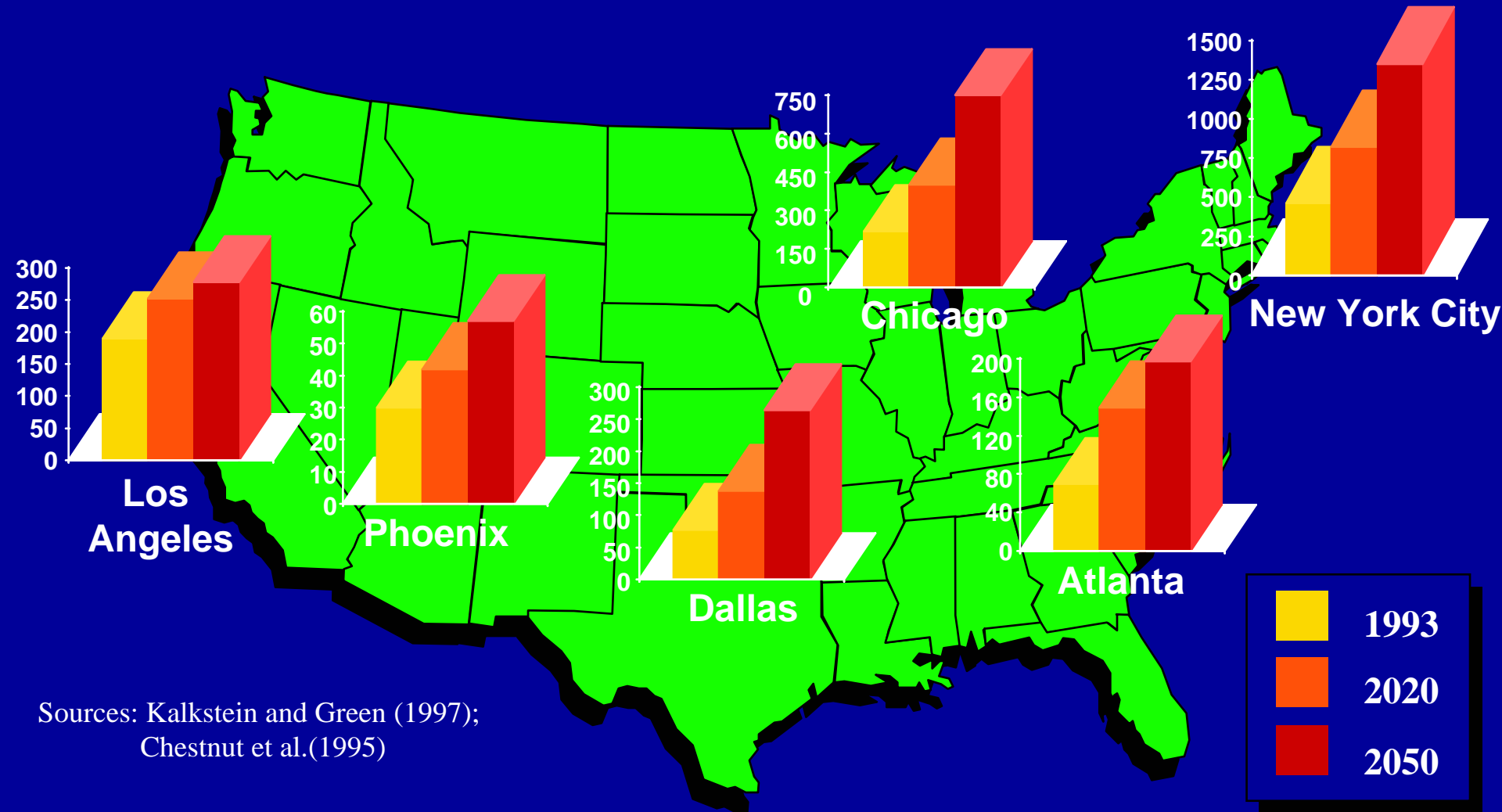


**Infectious
diseases**

The direct health effects of heat



Increased Mortality Risk During Heat Waves (1993, 2020 and 2050)



Sources: Kalkstein and Green (1997);
Chestnut et al.(1995)

Note: Includes both summer and winter mortality.
Assumes full acclimation to changed climate.
Includes population growth.

GFDL Climate Change Scenario



HEAT WAVE - EUROPE

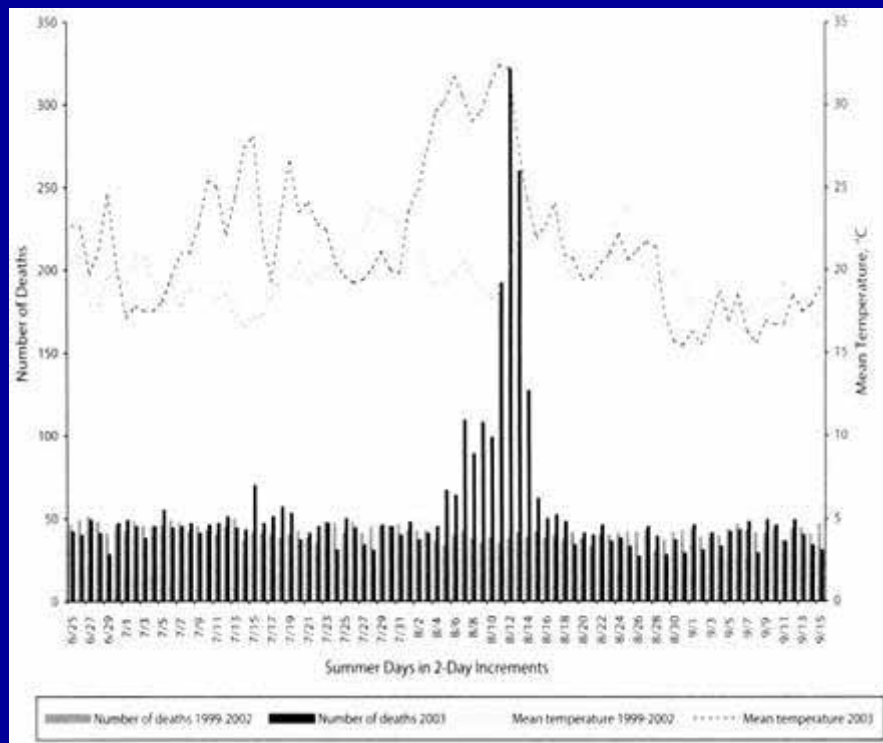


**approx.
30,000
deaths over
11 days**

Heat Index Summer 2003

European heat wave, 2003

CONFIRMED MORTALITY

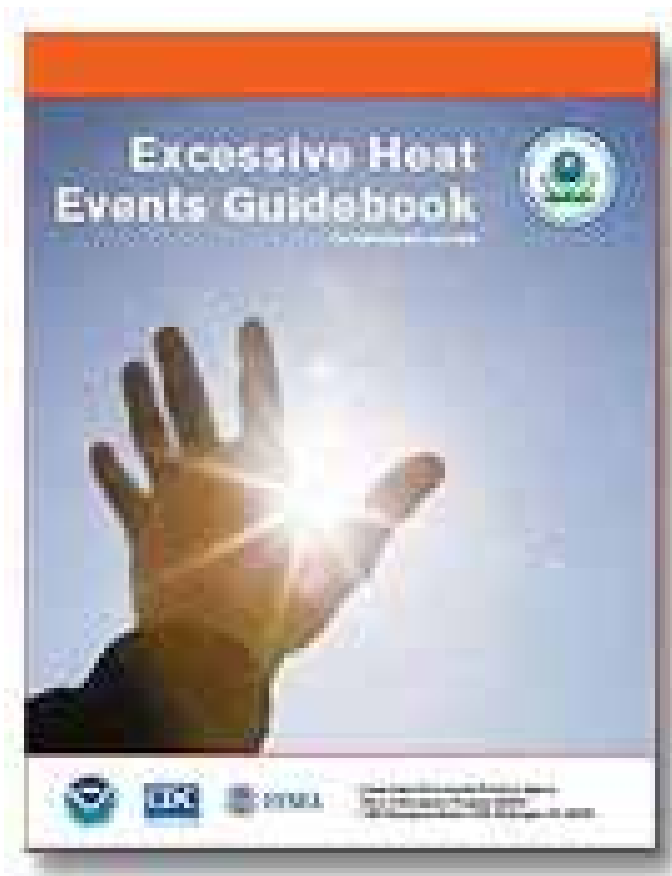


UK	2,091
Italy	3,134
France	14,802
Portugal	1,854
Spain	4,151
Switzerland	975
Netherlands	1,400-2,200
Germany	1,410
TOTAL	29,817-30,617

Vandendorren et al. Mortality in 13 French cities during the August 2003 heat wave. *Am J Public Health* 2004; 94(9):1518-20.

Haines et al. Climate change and human health: Impacts, vulnerability and public health. *Public Health* 2006;120:585-96.

EPA's "Excessive Heat Events Guidebook"



http://www.epa.gov/heatisland/about/pdf/EHEguide_final.pdf

nature

CLIMATE CHANGE

Regional health impacts
from North America to Africa

PLASMON OPTICS
Towards the perfect lens

EMERGING DISEASES
The Typhoid Mary factor

STAR FORMATION
Boost for a collapsing theory

- “The severity and duration of summertime regional air pollution episodes are projected to increase in the Northeast and Midwest US by 2045-2052 due to **climate-change-induced decreases in the frequency of surface cyclones.**” (IPCC, 2007)

- By 2050, warming alone may **increase by 68% the number of Red Ozone Alert days** across the Eastern US. (IPCC, 2007 -Bell et al, 2006)



Climate Change and Air Quality

- Climate change will likely affect air quality (e.g., ozone) in our cities
- Climate change may make it more difficult to attain air quality standards in certain areas
- “Climate penalty” may push areas that are in attainment into non-attainment
- Additional emissions reductions may be required in the future
- Opportunity to anticipate and adapt: We have an opportunity to begin folding considerations of climate change into our planning

Forthcoming: EPA Assessment of the Implications of Climate Change for Regional Air Quality in the U.S. (Spring 2008)

'Co-Benefits' of GHG Reduction

Fossil Fuels are source of GHGs and local air pollutants

- Deaths from Air Pollution ranked within top 10 causes of disability
- **800,000/yr avoidable deaths due to outdoor PM air pollution** (WHO, 1997)
- **3/4 of the world's 24 megacities are in developing countries; GHG mitigation --> major 'co-benefits'**
(Cifuentes et al 2001)



For Madison, if 20% of car trips were replaced by bike trips:

Grabow et al, in preparation

1. **10 lbs (4.5 kg) lost /person/yr** (for 6.8 mi. roundtrip commute)
2. **12% fall each in Ozone and NOx : 2% drop in PM_{2.5}**
 - **17,990 fewer lost-work days/yr**
 - **1,906 fewer Asthma admissions/yr**
 - **14,586 fewer acute respiratory cases/yr**
 - **\$40 million saved in health costs/yr**
3. **16,687 tons of CO₂ not emitted**

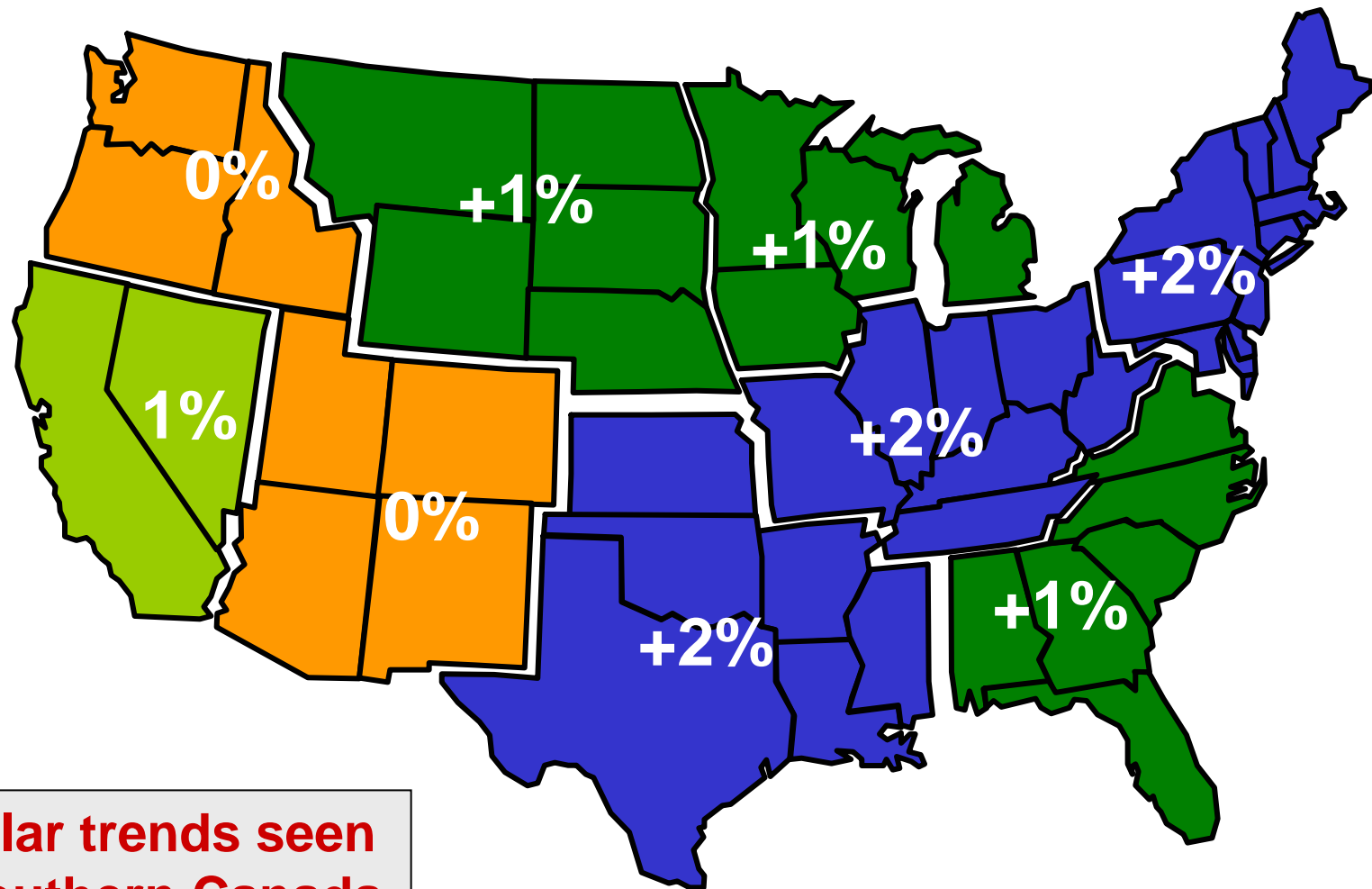
The Triple Win

**Climate change:
It's not just about
warming.**



More Rainfall Occurring in Intense Downpours

Trends in Proportion of Annual Precipitation of Extreme Intensity (*i.e.*, more than 2 in. per day): 1910-1995



Similar trends seen
in southern Canada

(Source: Karl and Knight, 1998)

USA: Combined sewer overflows (CSOs)



Courtesy: Kellogg Schwab



**1.2 trillion gal of sewage & stormwater a year
discharged during combined sewer overflows
– would keep Niagara Falls roaring for 18 days**

Center for Water & Health, JHU Bloomberg School of Public Health



Combined Sewer Overflow in the Great Lakes Region (Public review draft released in March 29th Federal Register Notice)

- Key Questions:
 - ✓ Does climate change matter to the redesign of combined sewer systems in the Great Lakes Region?
 - ✓ When the climate changes, how might CSO event frequency change, and in how many cases will the four CSO events per year threshold be exceeded?
- If combined sewer systems are designed to meet the EPA's CSO Control Policy design standard of 4 events per year, but fail to plan for climate change:
 - ✓ climate change may result in failure to meet the standard
 - ✓ **there could be an average of 237 events per year above the control policy's objectives across 182 communities**

TMDLs in the Great Lakes Region

(Public review draft released
in March 29th Federal Register Notice)

EPA's TMDL program
allocates pollutant loads
to water bodies



**Publicly-Owned Treatment
Works (POTW)**

Climate change could increase annual
POTW treatment costs in the Great Lakes
Region

- by \$8-\$97 million
- on impaired stream and river reaches
- further widening gap between funds
needed for POTWs and funds
available

Problem is manageable, but costly

Extreme Precipitation and Waterborne Disease Outbreaks in the United States, 1948 -1994

Project Sponsor:

US EPA, Office of Research & Development

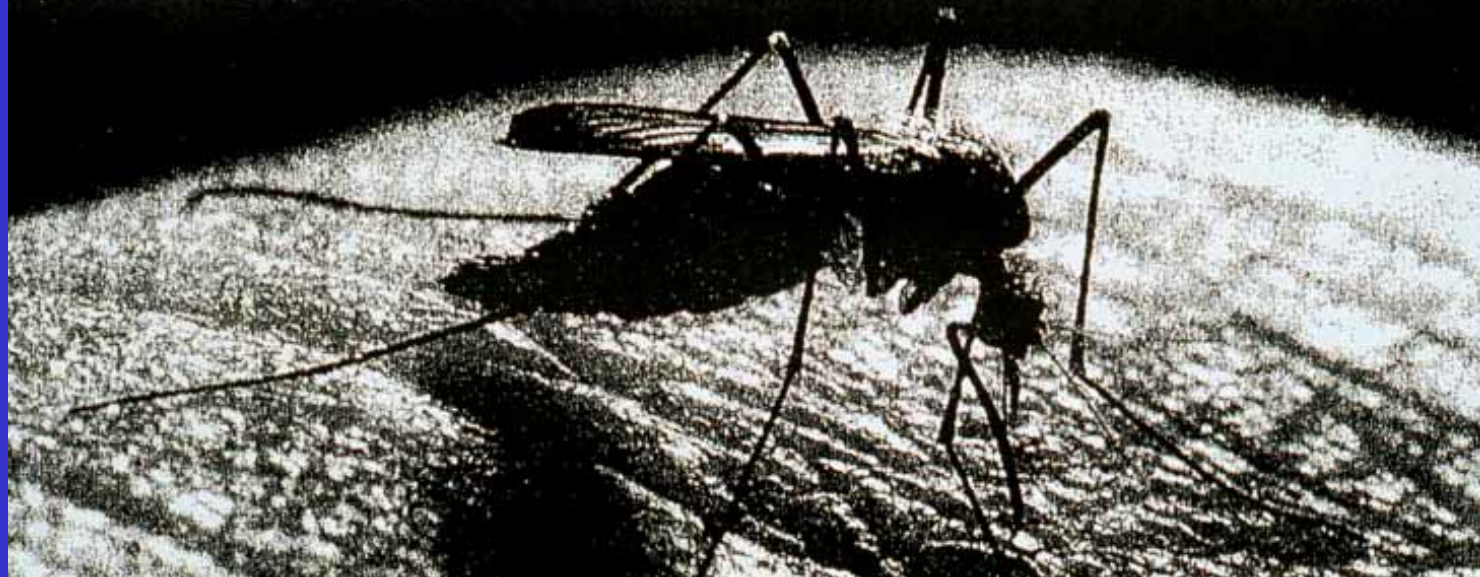
PI: J. Patz

Results

- **67%** of waterborne disease outbreaks were preceded by precipitation above the 80th percentile (across a 50 yr. climate record), $p < 0.001$
- **51%** of outbreaks were preceded by precipitation above the 90th percentile, $p < 0.002$
- Surface water-related outbreaks had strongest correlation with extreme precipitation in the month of outbreak; groundwater-related outbreaks lagged 2 months following extreme precipitation.

HEALTH PROFESSIONALS AND SCIENTISTS WARN OF SPREADING INFECTIOUS DISEASES.

Global Warming's **greatest** threat may also be the **smallest.**



CLIMATE CHANGE IMPACTS ON THE UNITED STATES

Ecosystem Models

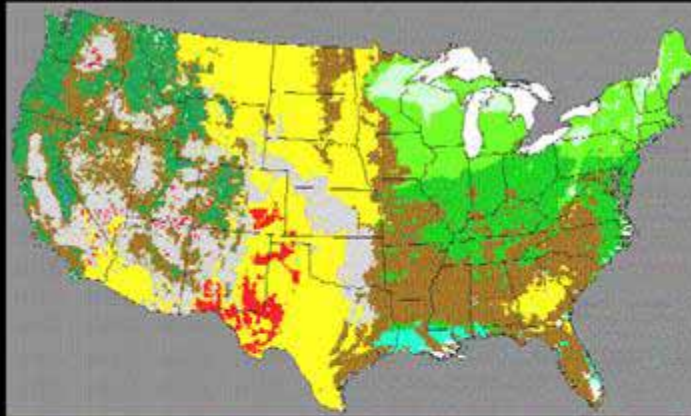
Maps of current and projected potential vegetation distribution for the conterminous US. Potential vegetation means the vegetation that would be there in the absence of human activity. Changes in vegetation distribution by the end of the 21st century are in response to two climate scenarios, the Canadian and the Hadley. Output is from MAPSS (Mapped Atmosphere-Plant-Soil System).

- Tundra
- Taiga / Tundra
- Conifer Forest
- Northeast Mixed Forest
- Temperate Deciduous Forest
- Southeast Mixed Forest
- Tropical Broadleaf Forest
- Savanna / Woodland
- Shrub / Woodland
- Grassland
- Arid Lands

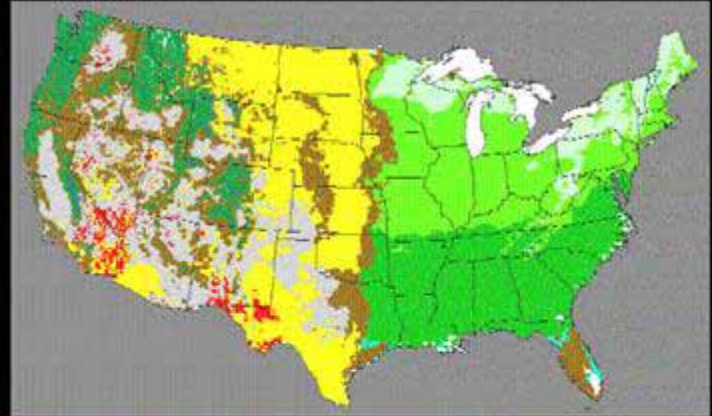
Current Ecosystems



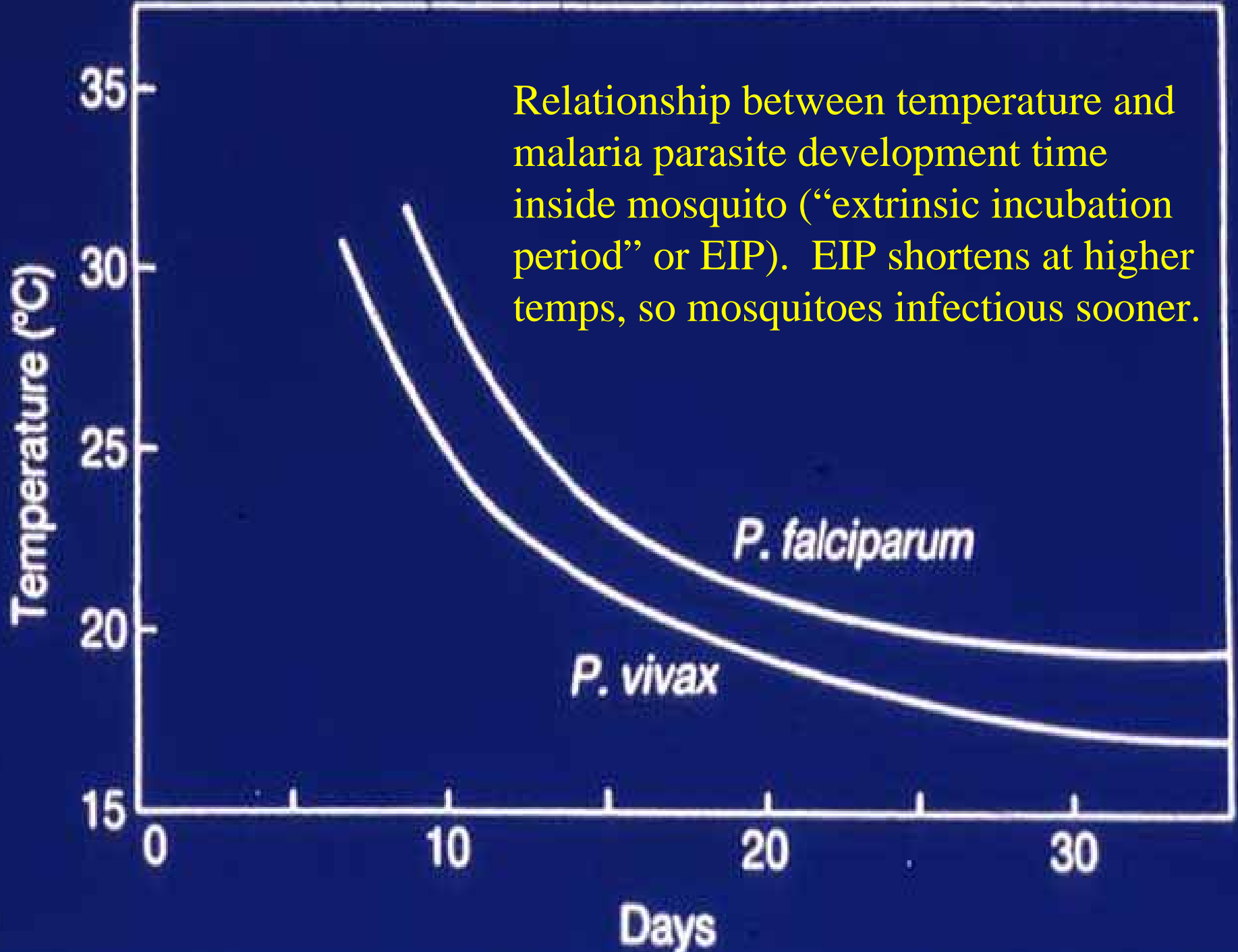
Canadian Model













Hadley Model



Relationship between temperature and malaria parasite development time inside mosquito (“extrinsic incubation period” or EIP). EIP shortens at higher temps, so mosquitoes infectious sooner.



Disease	Vector	Population at risk (million) ¹	Number of people currently infected or new cases per year	Present distribution	Likelihood of altered distribution
Malaria	Mosquito	2,400 ²	300-500 million	Tropics and Subtropics	
Schistosomiasis	Water snail	600	200 million	Tropics and Subtropics	
Lymphatic Filariasis	Mosquito	1 094 ³	117 million	Tropics and Subtropics	
African Trypanosomiasis (Sleeping sickness)	Tsetse fly	55 ⁴	250 000 to 300 000 cases per year	Tropical Africa	
Dracunculiasis (Guinea worm)	Crustacean (Copepod)	100 ⁵	100 000 per year	South Asia, Arabian Peninsula, Central-West Africa	
Leishmaniasis	Phlebotomine sand fly	350	12 million infected, 500 000 new cases per year ⁶	Asia, Southern Europe Africa, Americas	
Onchocerciasis (River blindness)	Black fly	123	17.5 million	Africa, Latin America	
American Trypanosomiasis (Chagas disease)	Triatomine bug	100 ⁷	18 million	Central and South America	
Dengue	Mosquito	1,800	10-30 million per year	All Tropical countries	
Yellow Fever	Mosquito	450	more than 5 000 cases per year	Tropical South America Africa	

1. Top three entries are population-prorated projections, based on 1989 estimates.

2. WHO, 1994.





3. Michael and Bundy, 1995.

4. WHO, 1994.

5. Ranque, personal communication.

6. Annual incidence of visceral leishmaniasis; annual incidence of cutaneous leishmaniasis is 1-1.5 million cases/yr (PAHO, 1994).

7. WHO, 1995.

 Highly likely  Very likely  Likely  Unknown

GRID 
Arendal UNEP
GRAPHIC DESIGN: PHILIPPE REKACIOWICZ



A rare genotype of *Cryptococcus gattii* caused the cryptococcosis outbreak on Vancouver Island (British Columbia, Canada)

S. E. Kidd^{*†‡}, F. Hagen[§], R. L. Tscharke[¶], M. Huynh[†], K. H. Bartlett[‡], M. Fyfe^{||}, L. MacDougall^{||}, T. Boekhout^{§**}, K. J. Kwon-Chung[¶], and W. Meyer^{*†.††}

Discussion

Until the recent emergence of cryptococcal infection on Vancouver Island, *C. gattii* had been considered to be restricted to areas with tropical and subtropical climates (2). The identification of large-scale colonization of *C. gattii* in the environment occurring in a temperate climate zone indicates a striking change in the distribution of this species. Furthermore, the identification of the *C. gattii*

Fatal fungus spreads in Northwest

By [Doug Struck](#)

Washington Post Foreign Service

Sunday, April 8, 2007; Page D01

VICTORIA, B.C. -- The mystery emerged slowly, its clues maddeningly diverse.

Sally Lester, an animal pathologist at a British Columbia laboratory, slipped a slide under her microscope -- a tissue from a dog on Vancouver Island. Her lens focused on a tiny cell that looked like a boiled egg. It was late 1999. She had started seeing a lot of those.

On the eastern side of the island, several dead porpoises washed ashore early the next year. Scientist Craig Stephen, who runs a research center on the island, slit one open. He found its lungs seized by pneumonia and its other organs swollen by strange, flowerlike tumors.

At work at the family traveling firm in

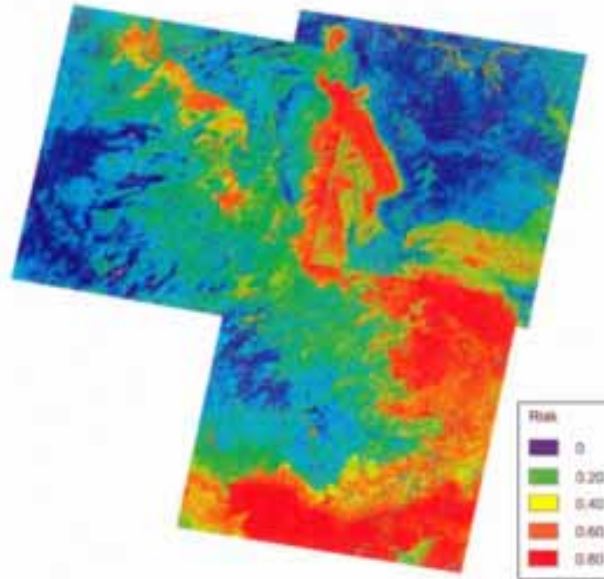
"As climate change happens, new ecological niches will become available to organisms, and we will see this kind of thing happen again," said Karen Bartlett, a scientist at the University of British Columbia who played a central role in the search for the disease's cause.

Her investigation eventually would focus on a fungus, a member of the yeast family called *Cryptococcus gattii*. The microscopic fungus is normally found in the bark of eucalyptus trees in Australia and other tropical zones.

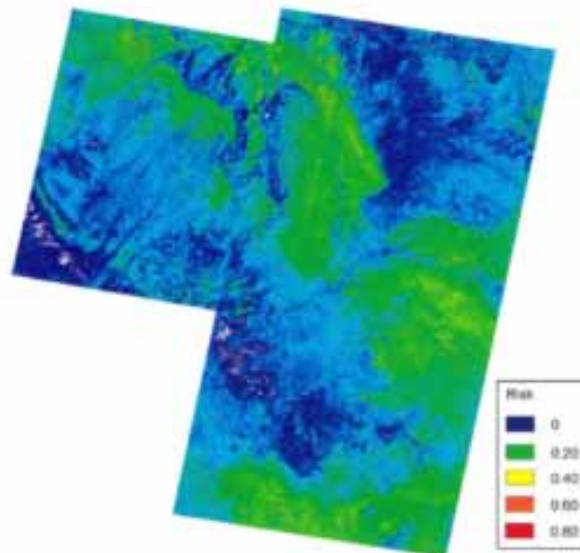
Success Story: Informing Public Health Interventions to Prevent Hantavirus Pulmonary Syndrome in the Southwestern United States

- Illustrates how ORD health-impacts assessment can ultimately lead to on-the-ground interventions to prevent disease and protect the public's health
- 1993: HPS outbreak in SW with high death rate (>50%)
- Hypothesis: outbreak due to environmental conditions and increased rodent populations caused by unusual weather associated with 1991-92 ENSO
- EPA-sponsored study at The Johns Hopkins School of Hygiene and Public Health explored this hypothesis
- Found that high-risk areas for HPS can be predicted over 6 months in advance based on satellite generated risk maps of climate-dependent land cover.
- **Risk maps**, developed in partnership with CDC and the Indian Health Service, are already being implemented for disease prevention in the southwest by the U.S. Department of Health and Human Services.

Hantavirus Pulmonary Syndrome
Southwestern, USA - 1992



Hantavirus Pulmonary Syndrome
Southwestern, USA - 1995



Health Sector Assessments

- **2001 Health Sector Assessment (HSA)**
 - Examined five health outcomes
 - ✓ temperature-related morbidity and mortality
 - ✓ extreme weather events such as storms and floods
 - ✓ air pollution
 - ✓ water- and food-borne diseases
 - ✓ vector- and rodent-borne diseases
 - Overall conclusion: “...multiple levels of uncertainty preclude any definitive statement on the direction of potential future change for each of the health outcomes assessed.”
 - Also stressed the need to maintain and improve public health systems and their responsiveness to changing climate conditions
 - Identified a list of **30** research needs and knowledge gaps

Health Sector Assessments (cont.)

- 2005 EPA-commissioned report:
“Climate change and human health impacts in the United States: An update on the results of the U.S. National Assessment” [Kristie Ebi, David Mills, Joel Smith]
 - Literature published since 2001 supports HSA conclusion
 - But some improvements in understanding of potential effects
 - ✓ Refined understanding of mortality-heat stress relationship
 - ✓ Quantified impact of urban heat islands on ambient air temperatures
 - ✓ Continued development of morbidity and mortality data sets
 - ✓ Advances in epidemiologic modeling techniques have refined quantitative exposure-response relationships in various health outcome areas