Climate Change and Human Health

MIT

Paul R. Epstein, MD, MPH

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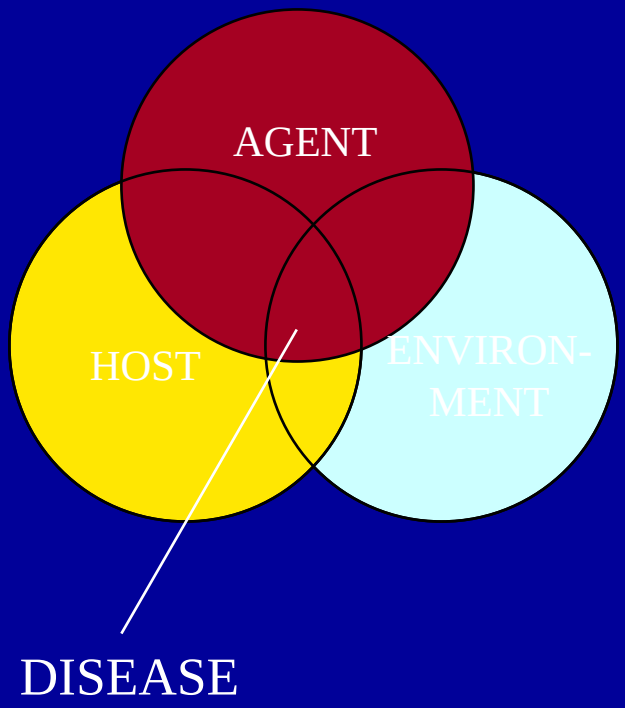
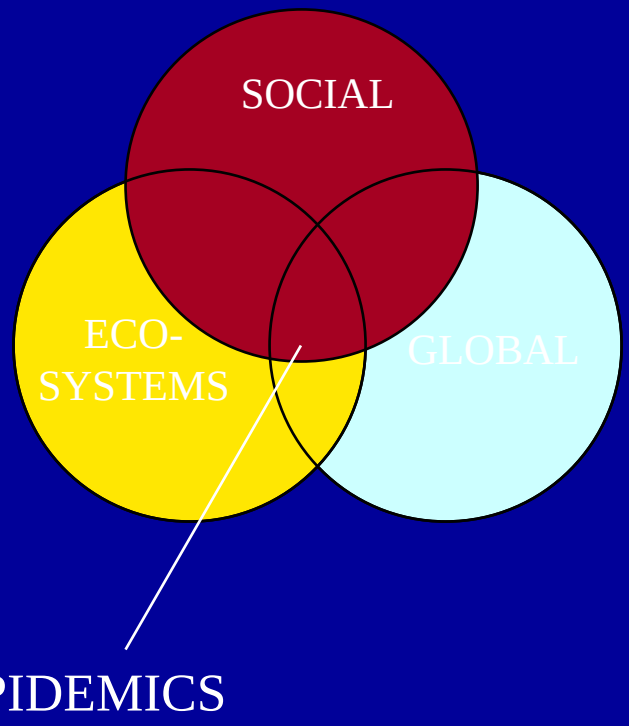
Epidemiological Framework



Ecological-Epidemiological Framework



United Nations Intergovernmental Panel on Climate Change Third Assessment Report 2001

1. Climate is changing
2. Human activities are contributing
3. Biological systems are being affected on all continents
4. Weather is becoming more extreme

All weather = *f* (CC + NV)

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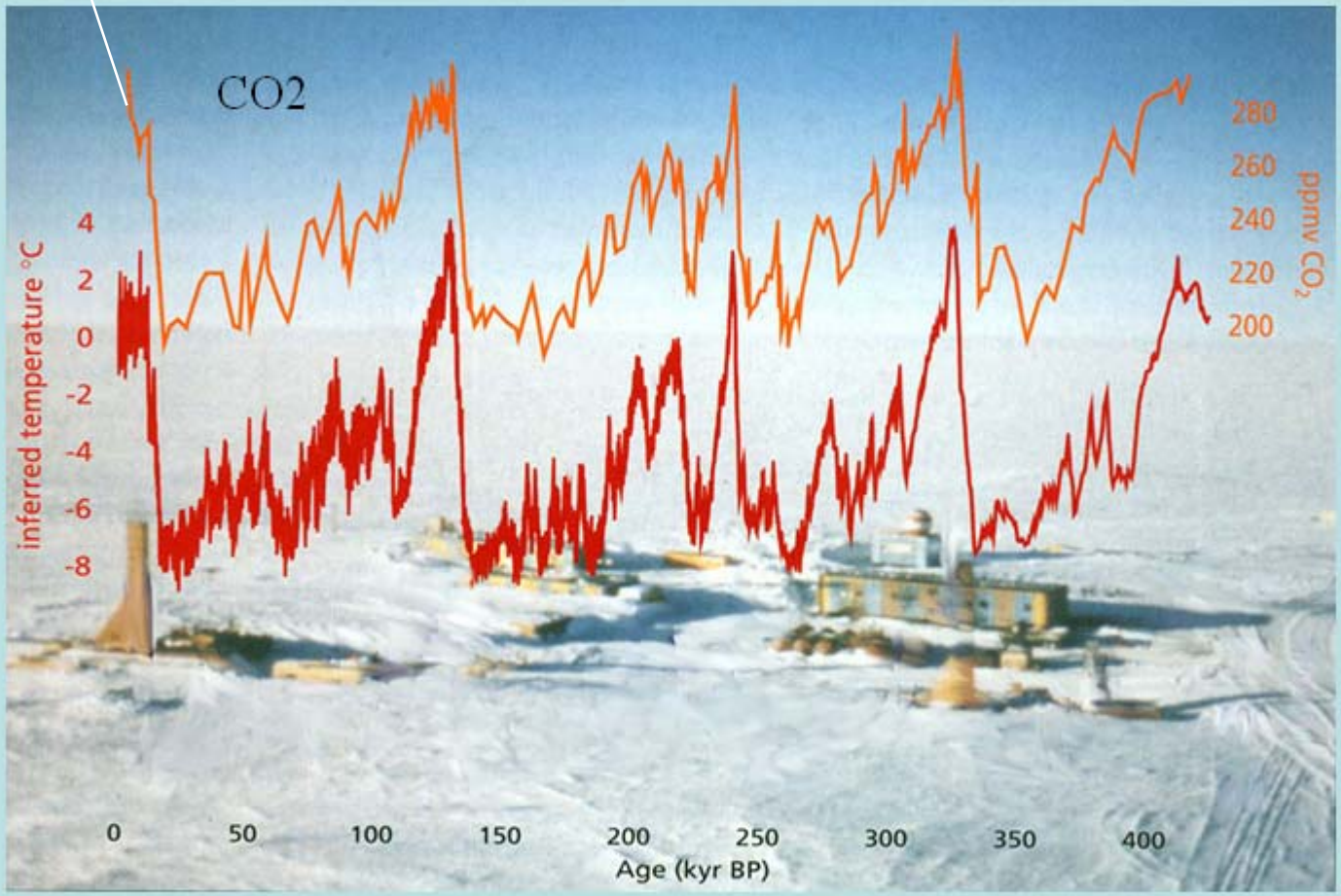
379ppm



TM

Vostok Ice Core

Since 2001, studies show:

- CO_2 rise is accelerating, 3ppm/yr, up from 1.8
- Tropical oceans are warmer and saltier, surface waters near the poles are cooler and fresher
- Polar and mountain glacial ice is diminishing at surprising rates
- Winds around both poles are becoming more forceful.

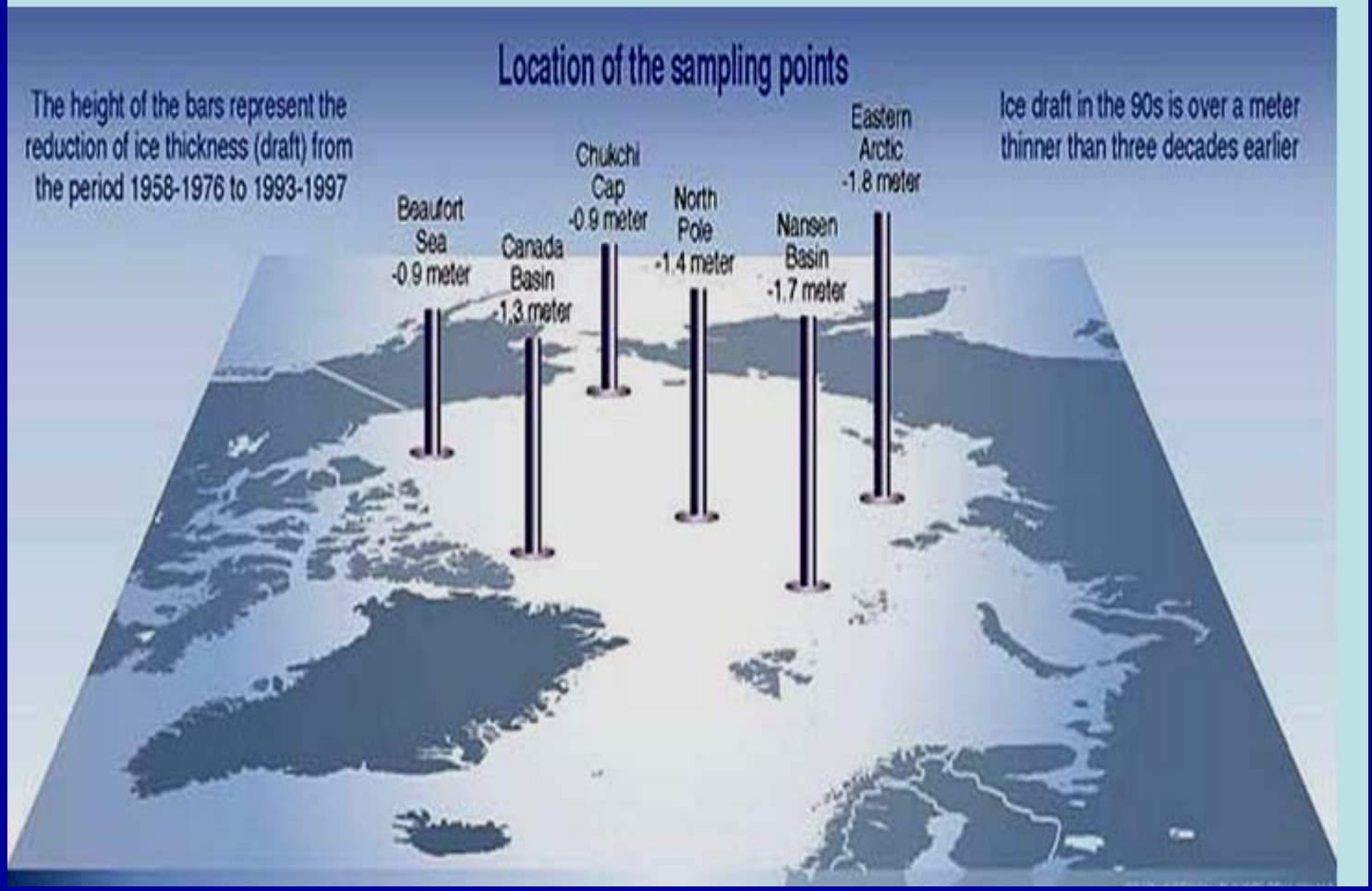
Deep Ocean Warming

Oceans: 14.2×10^{22} J
Atmosphere: 6.6×10^{21} J

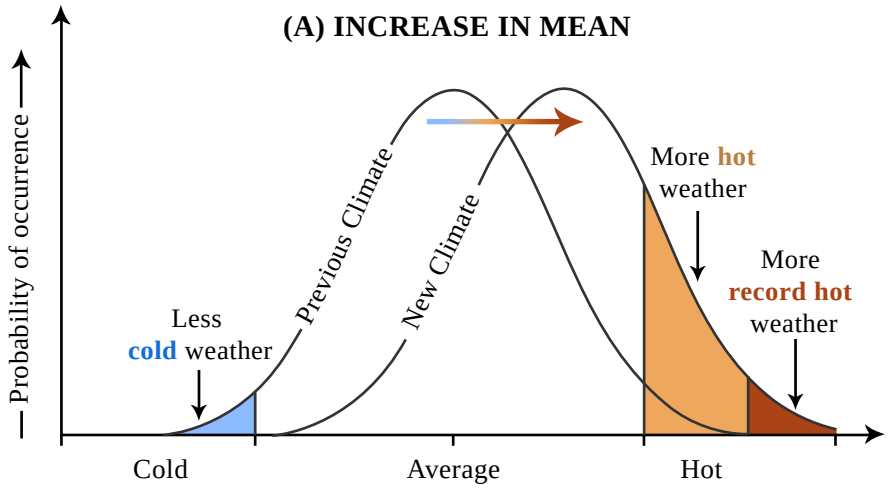
Levitus et al. *Science* 2000; 287:2225

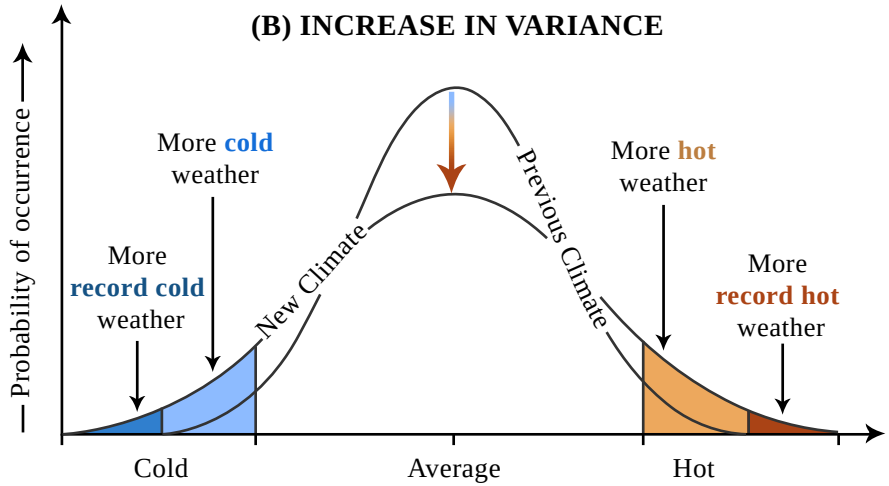
Parrilla et al. *Nature 1994;369:48*

Observed Thinning of Arctic Sea-Ice 1960s - 1990s



The Changing Shape of the Curve





(C) INCREASE IN MEAN AND VARIANCE

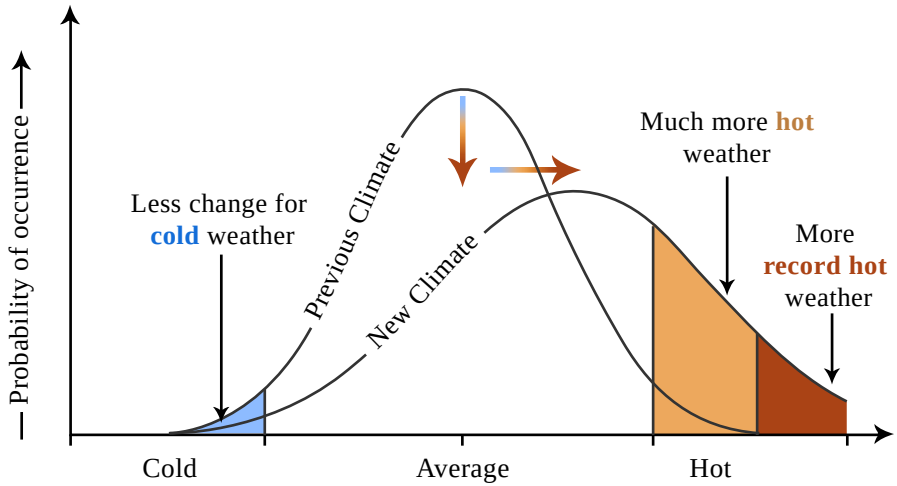
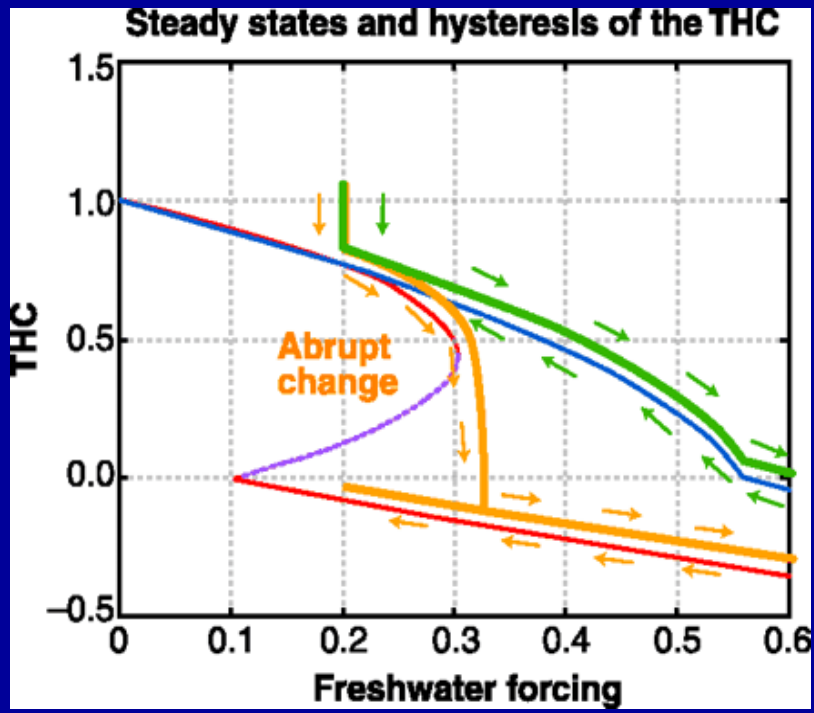


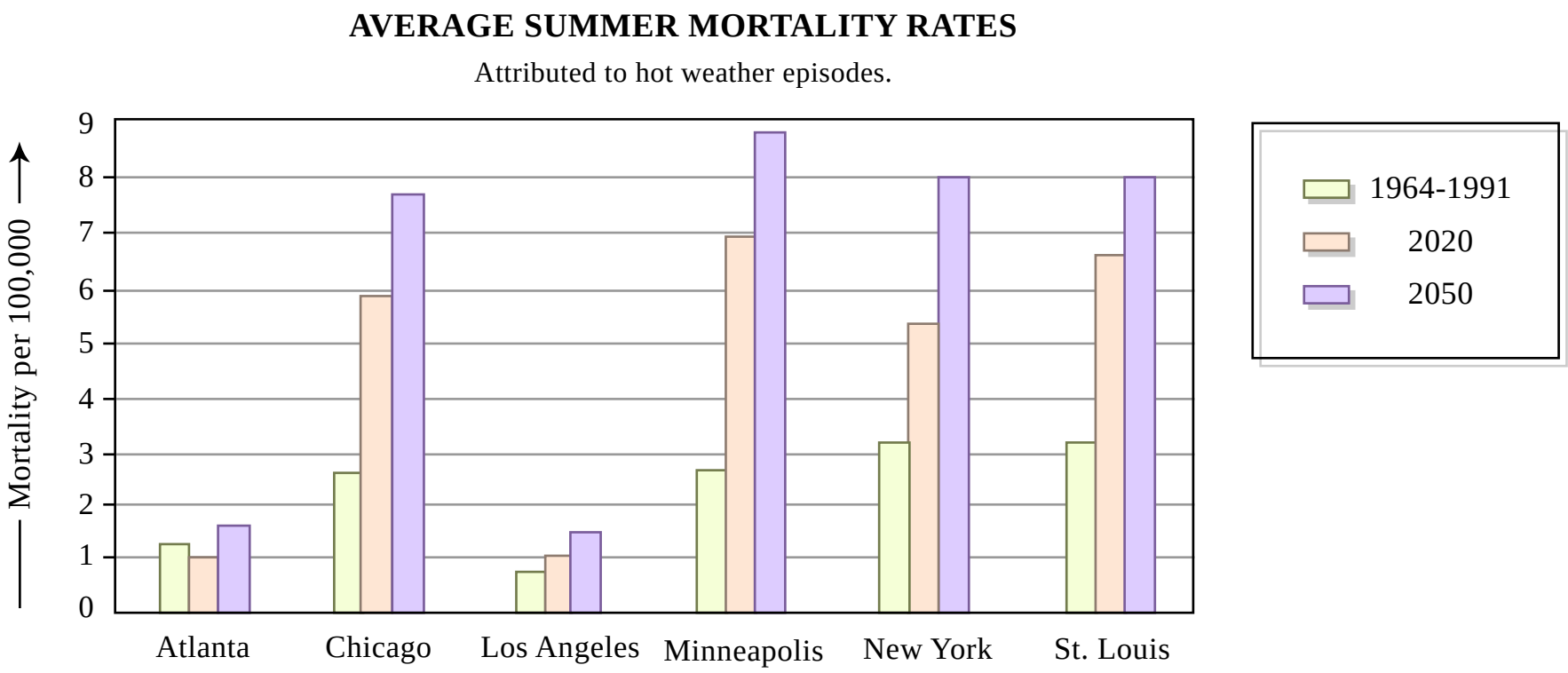
Figure by MIT OCW.

Assessing Climate Stability

- Rates of Change
  - Variability
    - Gradients
      - Number of Components Changing



Model Projections: Heat Waves



Estimates for 2020 and 2050 are based on the Max Planck GCM results (IPCC 1994)

Summer 2003 Heat Wave

France, Germany, Italy, Spain, Portugal 21-35, 000 Deaths

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Source: NASA

2003 Summer Temperatures
10°C (18°F) >30year average

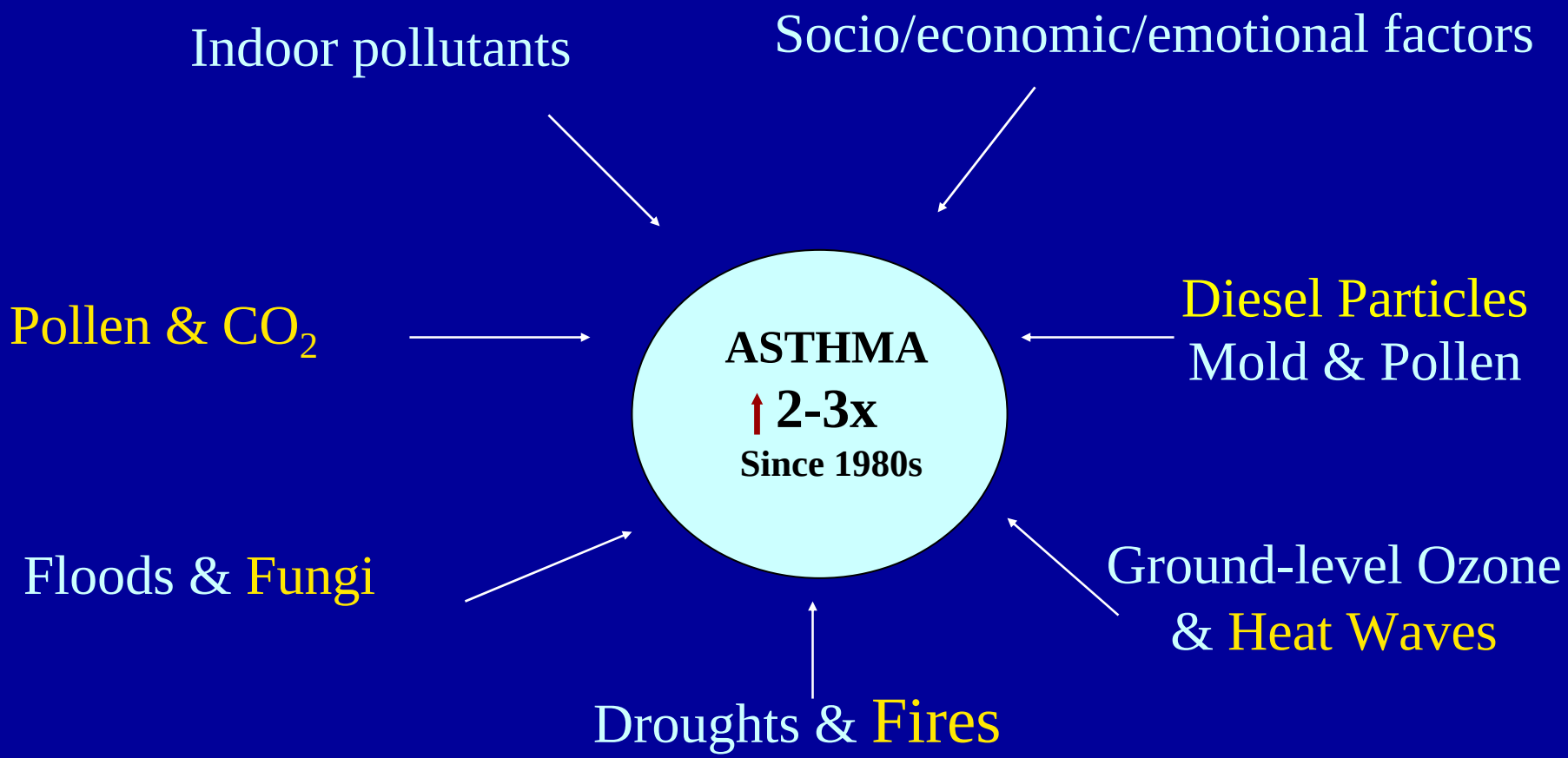
INDIA

June 2003 T 122°F >1400 deaths

July Floods

Japanese B encephalitis

Air Pollution and Climate Change



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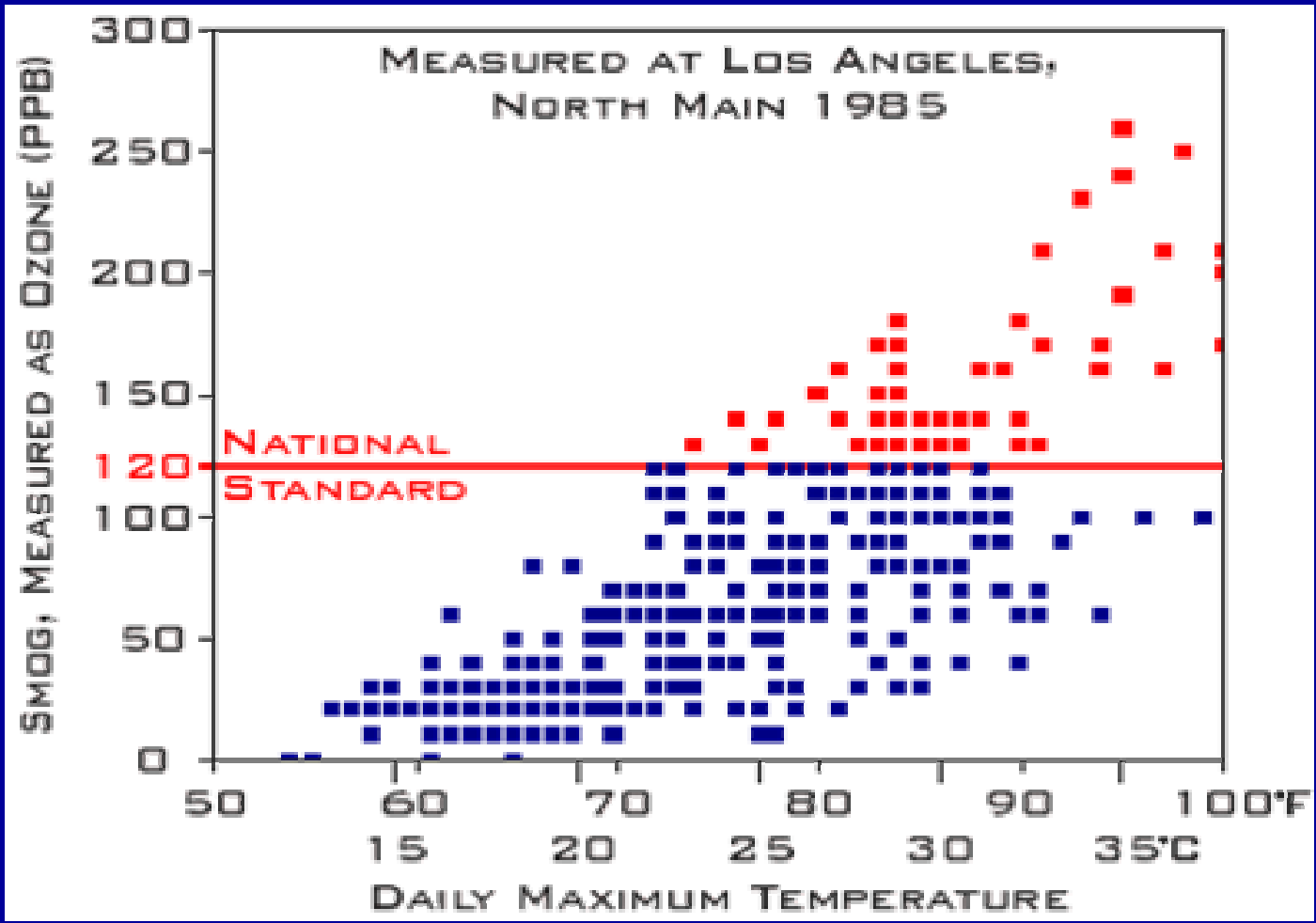
Ground-level Ozone And Temperature



RAGWEED POLLEN PRODUCTION and CO_2

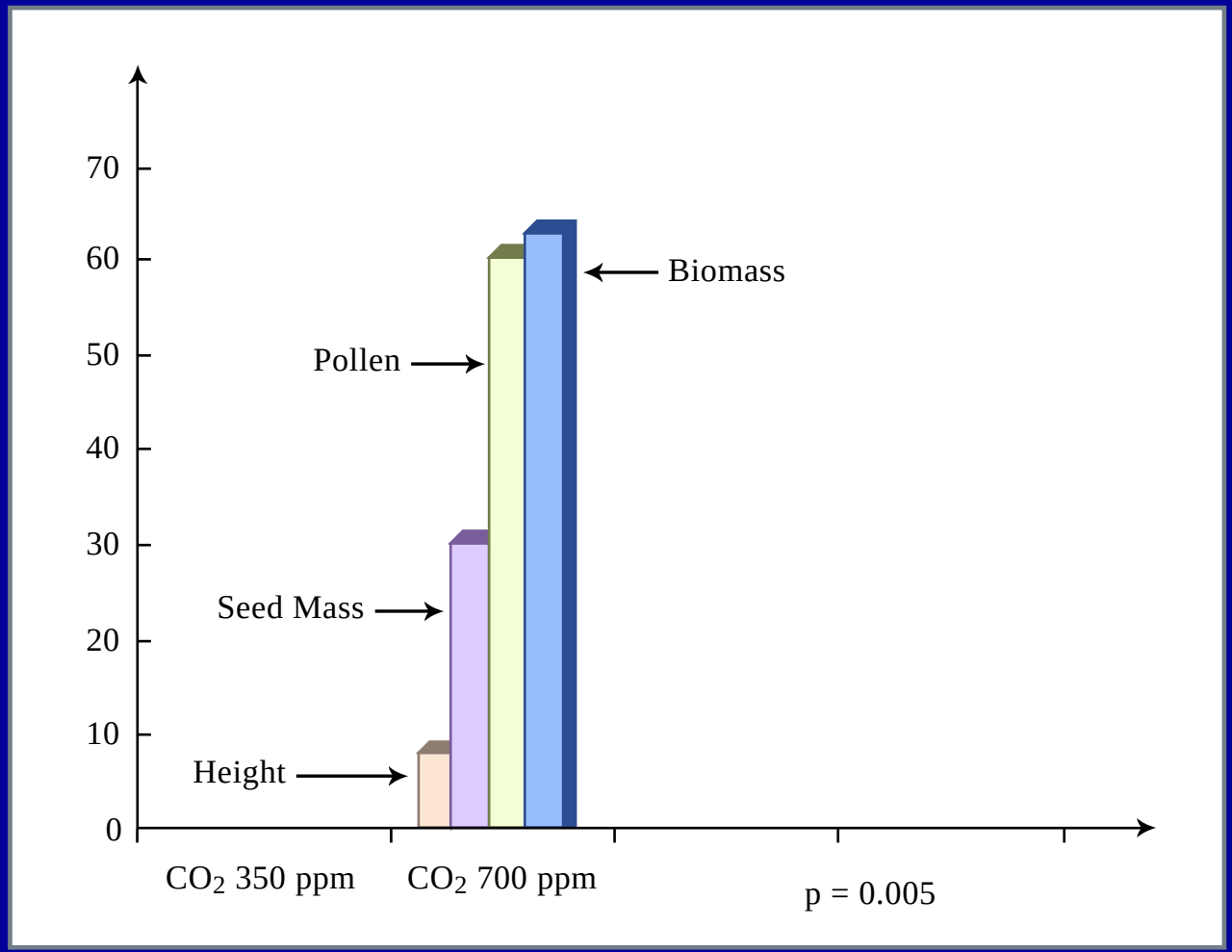
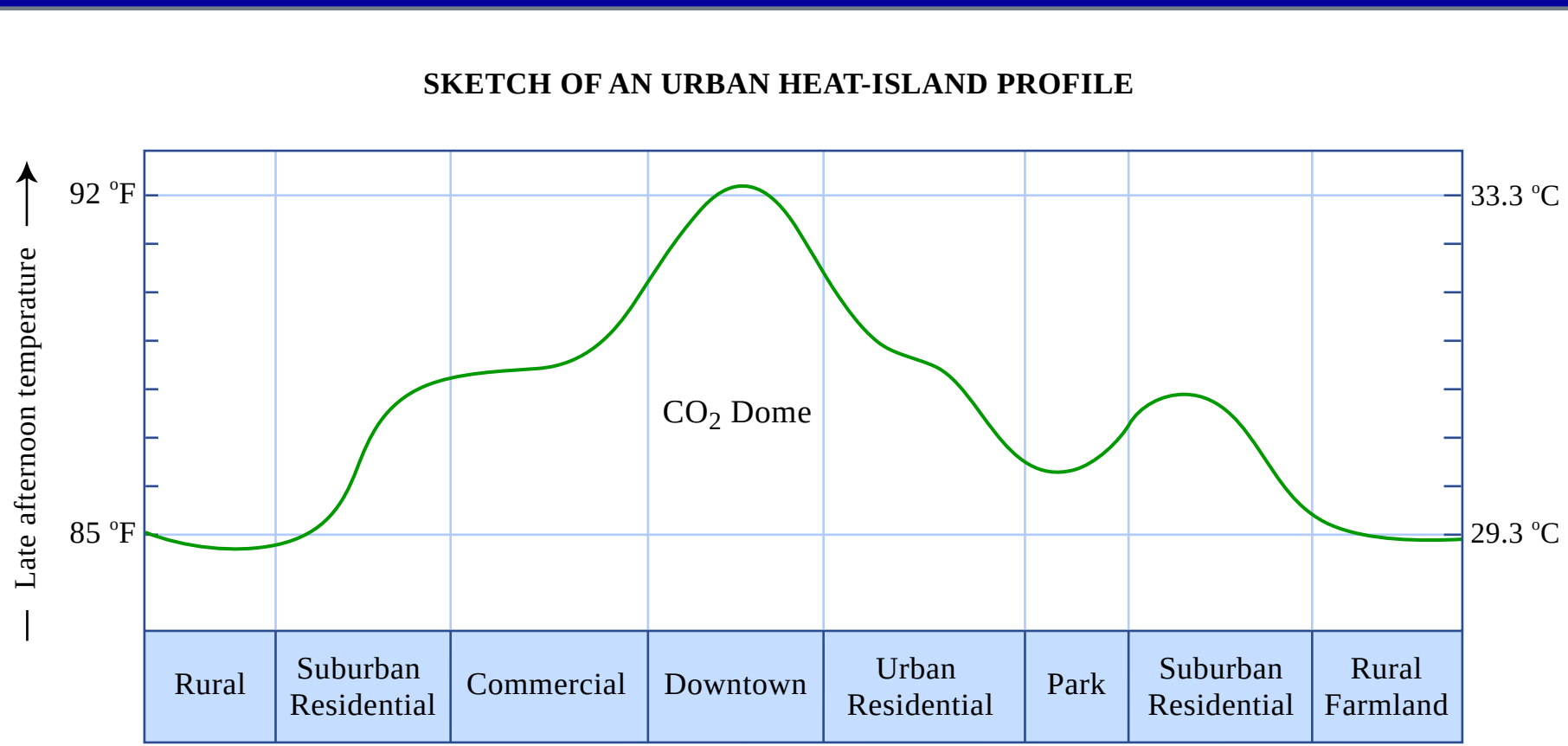


Figure by MIT OCW.



Emerging Infectious Diseases

30 "NEW" TO MEDICINE SINCE 1976

HIV/AIDS **Legionnaires'**

***E. coli* O157:H7** **MDRTB & others**

SARS **nvCJD**

HPS ***Vibrio cholerae* O139**

Nipah virus **Ebola**

Arenaviruses **Lyme disease**

RESURGENT & REDISTRIBUTING

Malaria, DF, WNV, Leptospirosis,

Cholera, Avian Flu

VECTORS

Mosquitoes
Ticks
Rodents
Bats
Tsetse Flies
Fleas
Lice
Snails
Algae

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Infectious Disease: A Driving Force In History

The Bad News:

PLAGUE

541 AD

1346 AD

The "Good" News

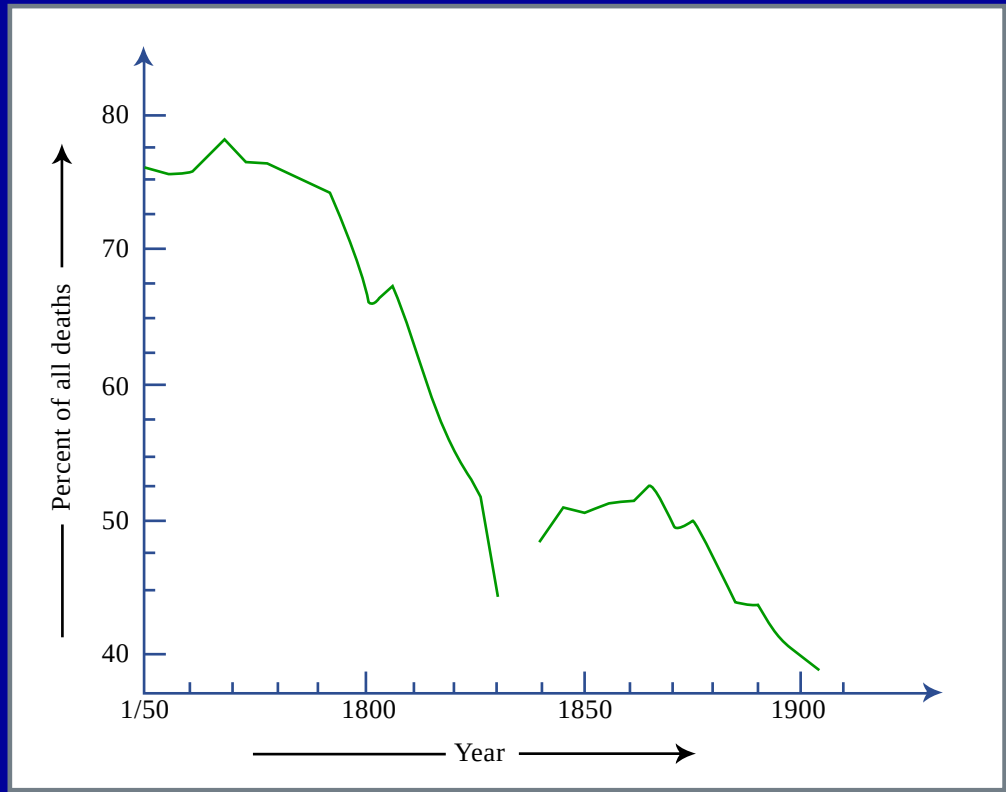

Figure by MIT OCW.

Deaths from IDs in London
Cholera, TB, Smallpox

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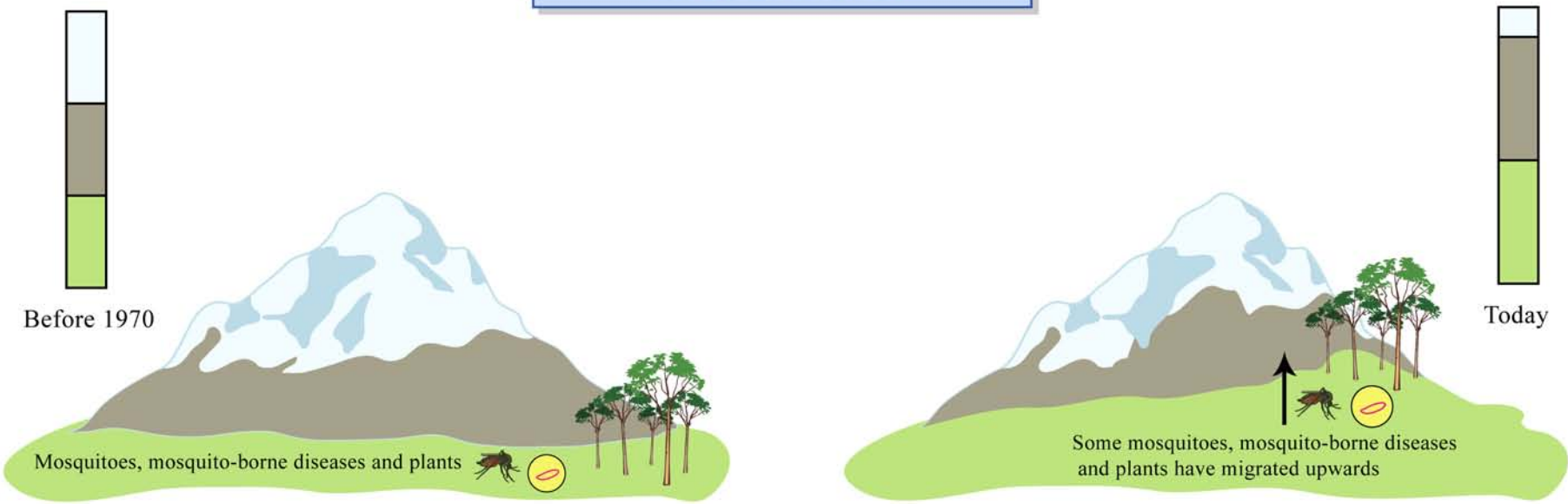
MONTANE REGIONS



Before 1970 ----- Cold temperatures caused freezing at high elevations.

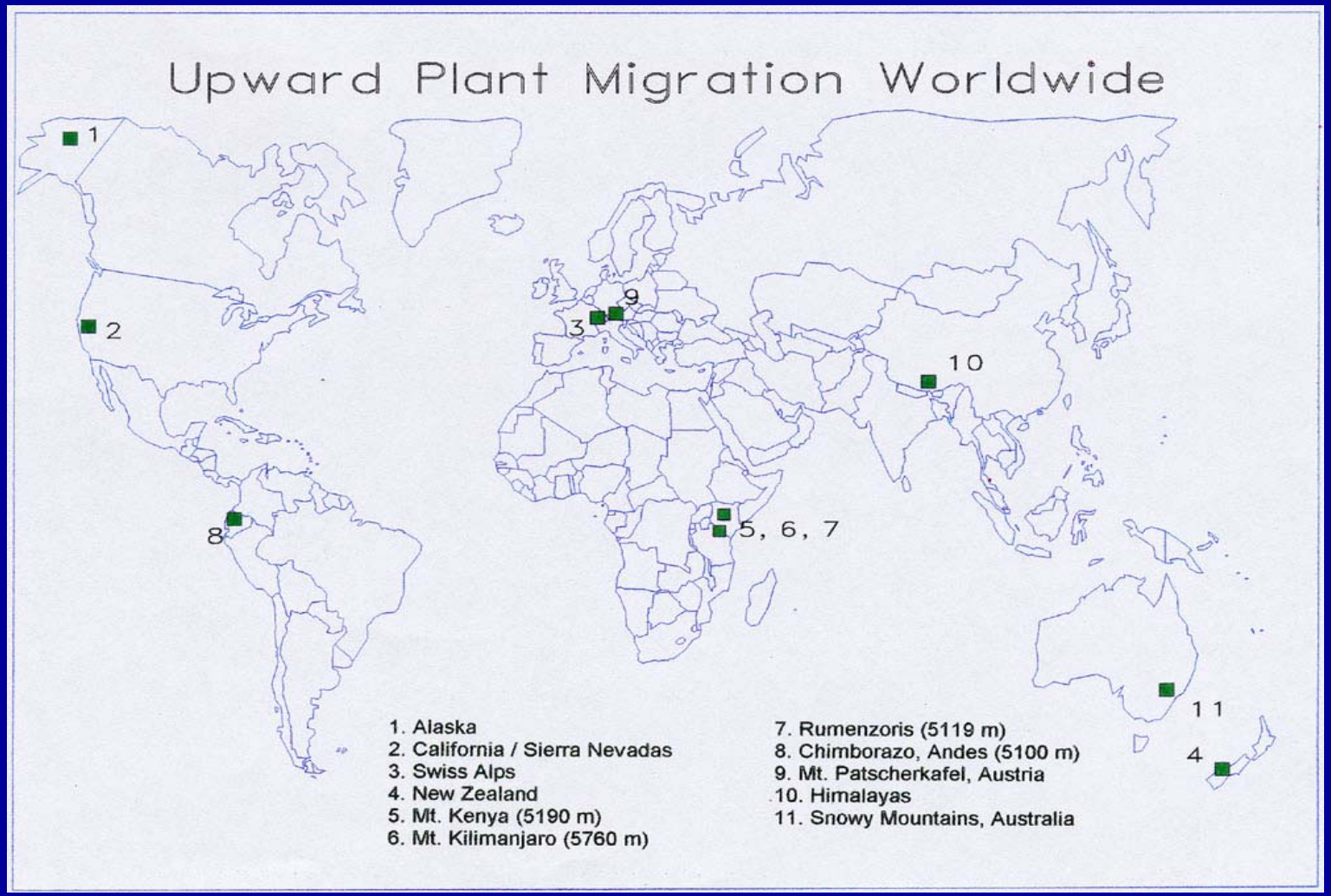
Result - Limited mosquitoes, mosquito-borne diseases (dengue fever or malaria) and many plants to low altitudes.

Today ----- Increased warmth has caused mountain glaciers to shrink in the tropics and temperate zones.

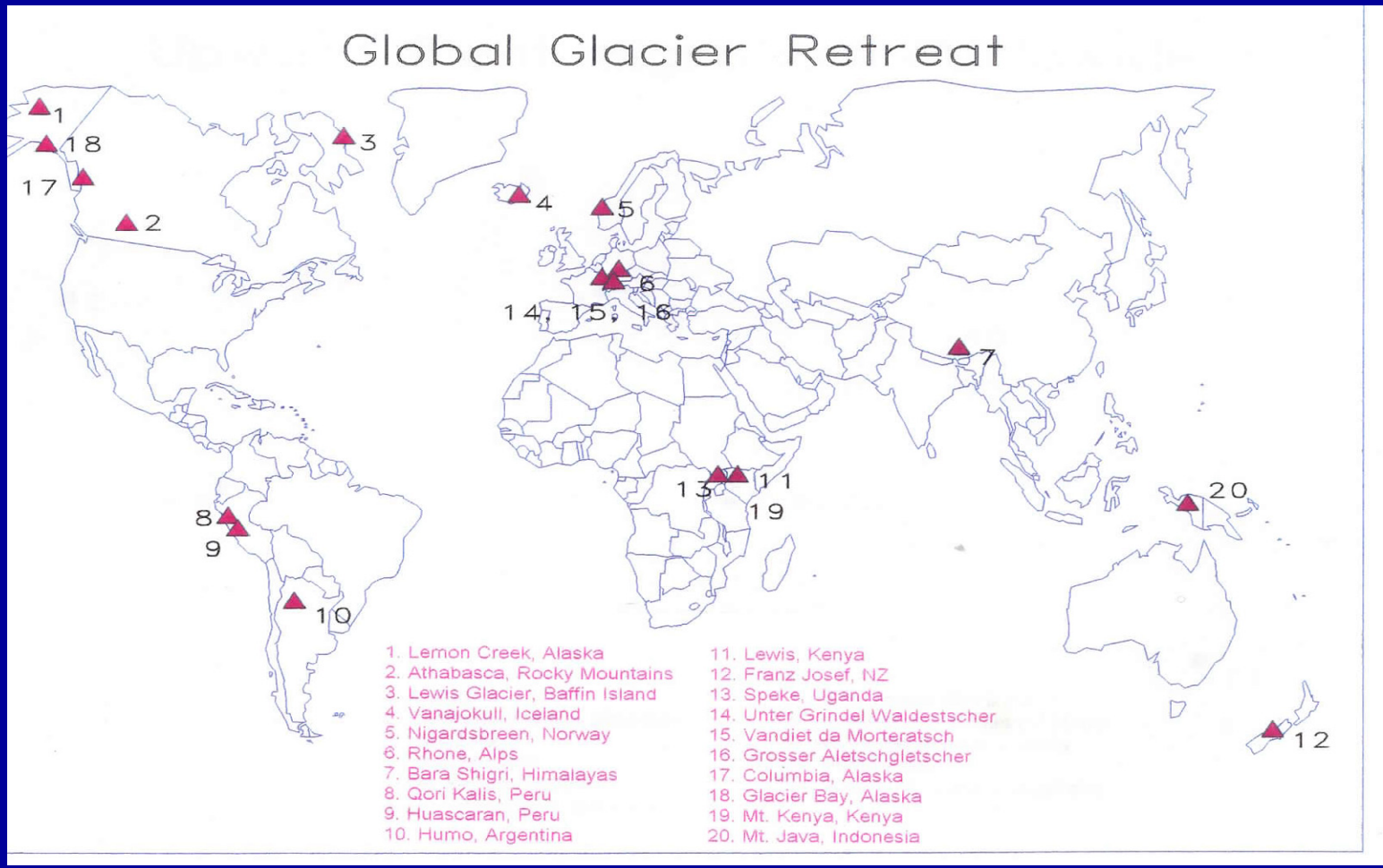
Result - Some mosquitoes, mosquito-borne diseases (dengue fever or malaria) and plants have migrated upward.

Figure by MIT OCW.

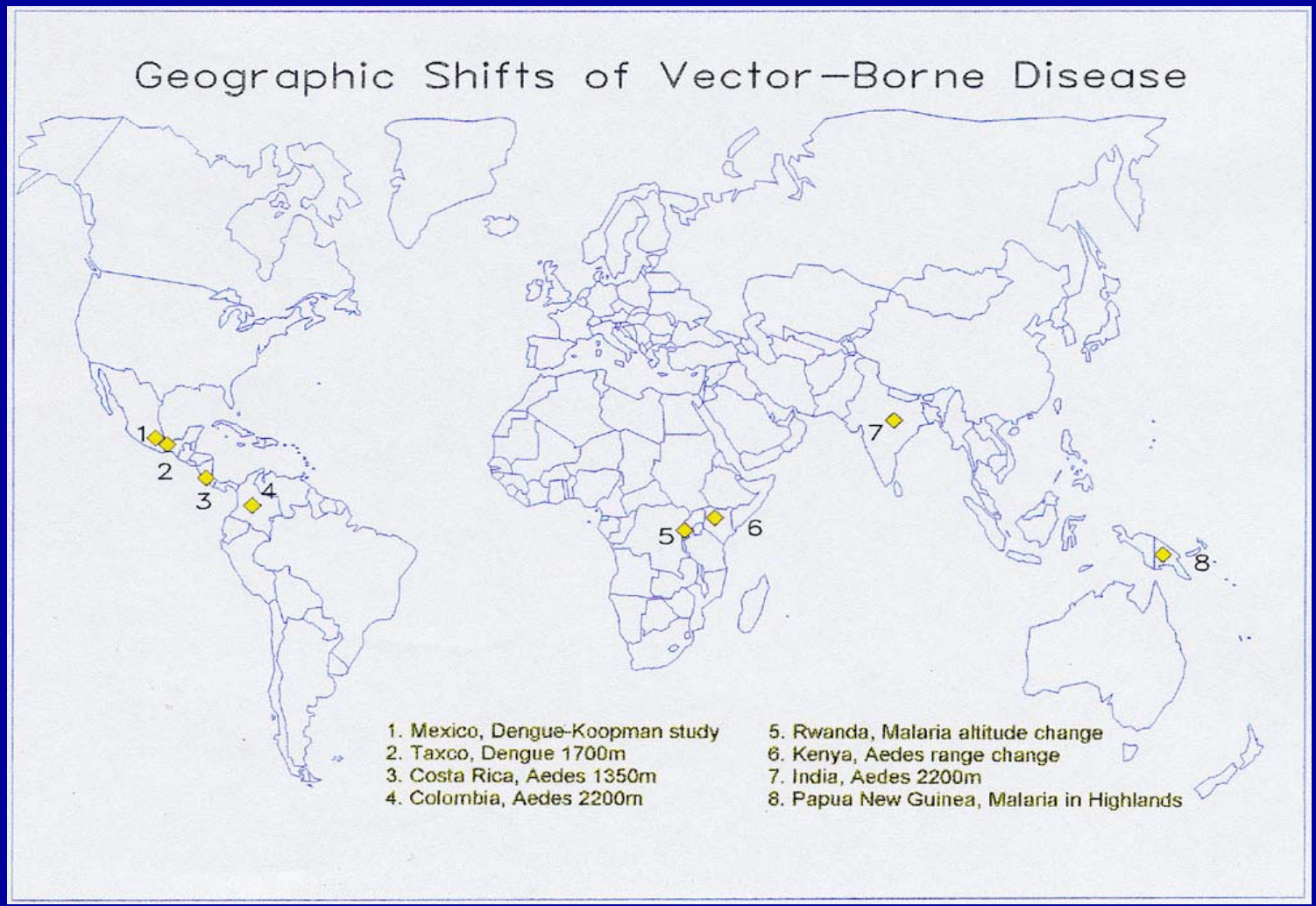
Upward Plant Migration



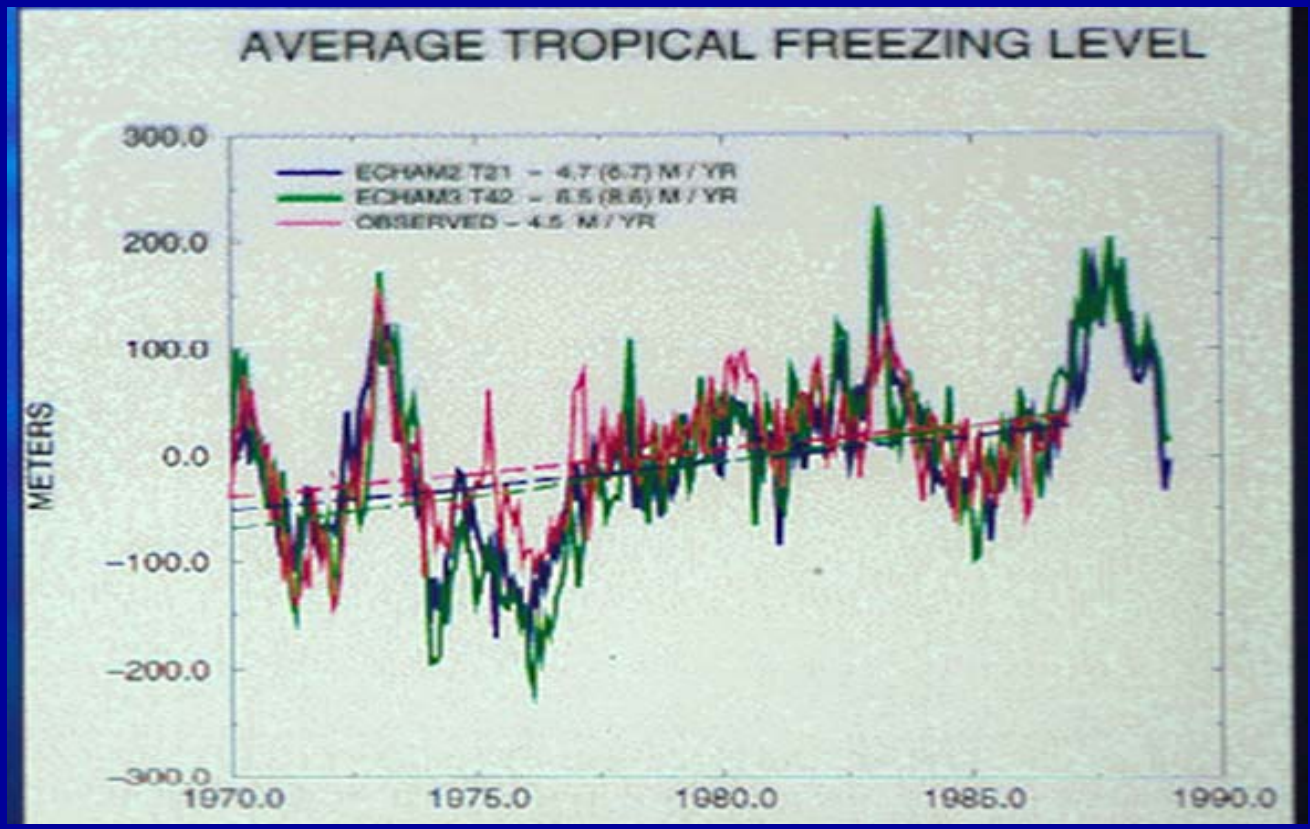
Changes in the Cryosphere



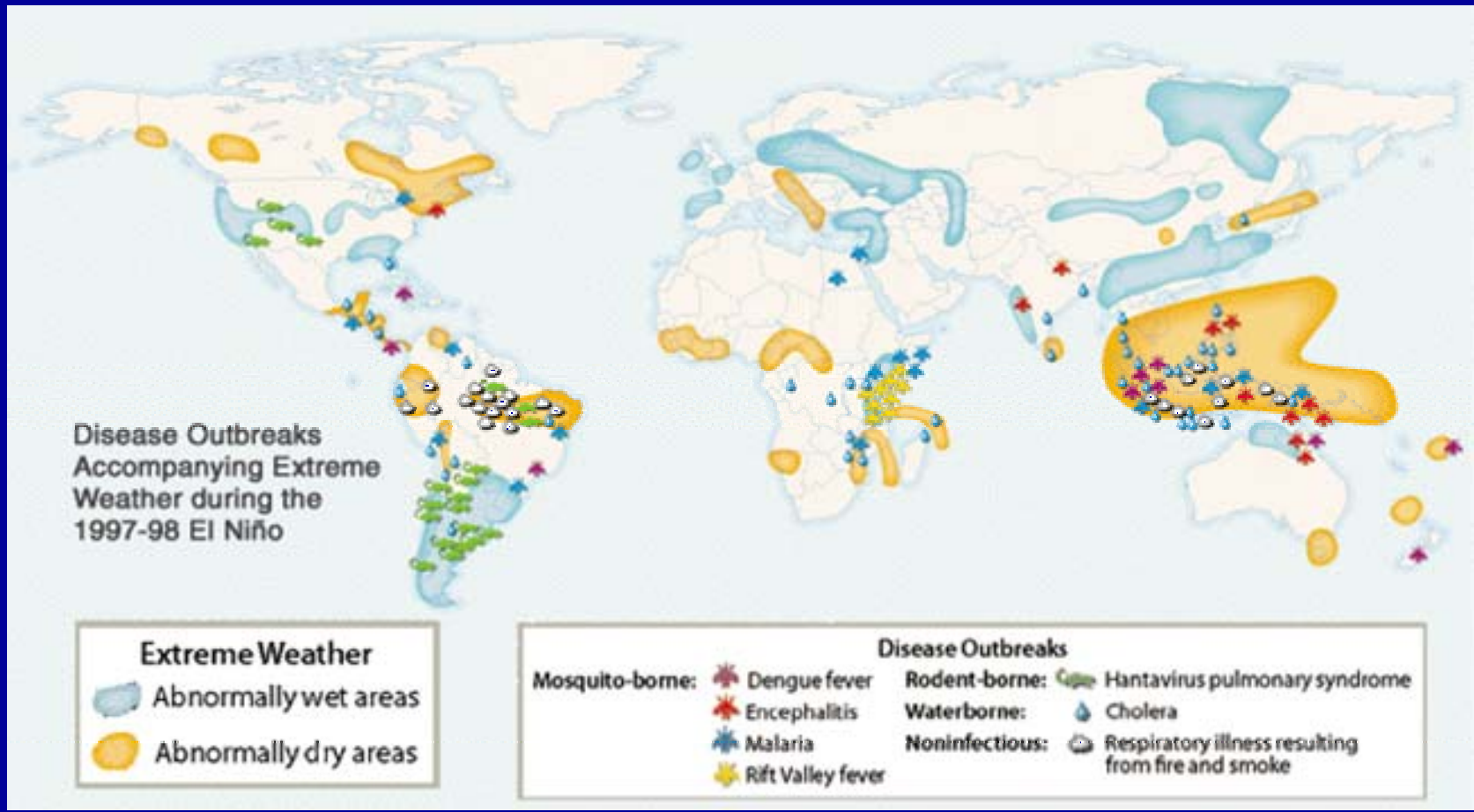
Geographic Shifts of Disease Vectors



Changes in Permafrost



Extreme Weather Events & Disease Clusters



Precipitation Extremes

Past century average annual precipitation: ⇑ 7%

"Heavy rain events" (>2"/day): ⇑ 14%

"Very heavy rain events" (>4"/day): ⇑ 20%

Western drought – worst in 500 years. Devastating rains 2005

Groisman et al. 2004

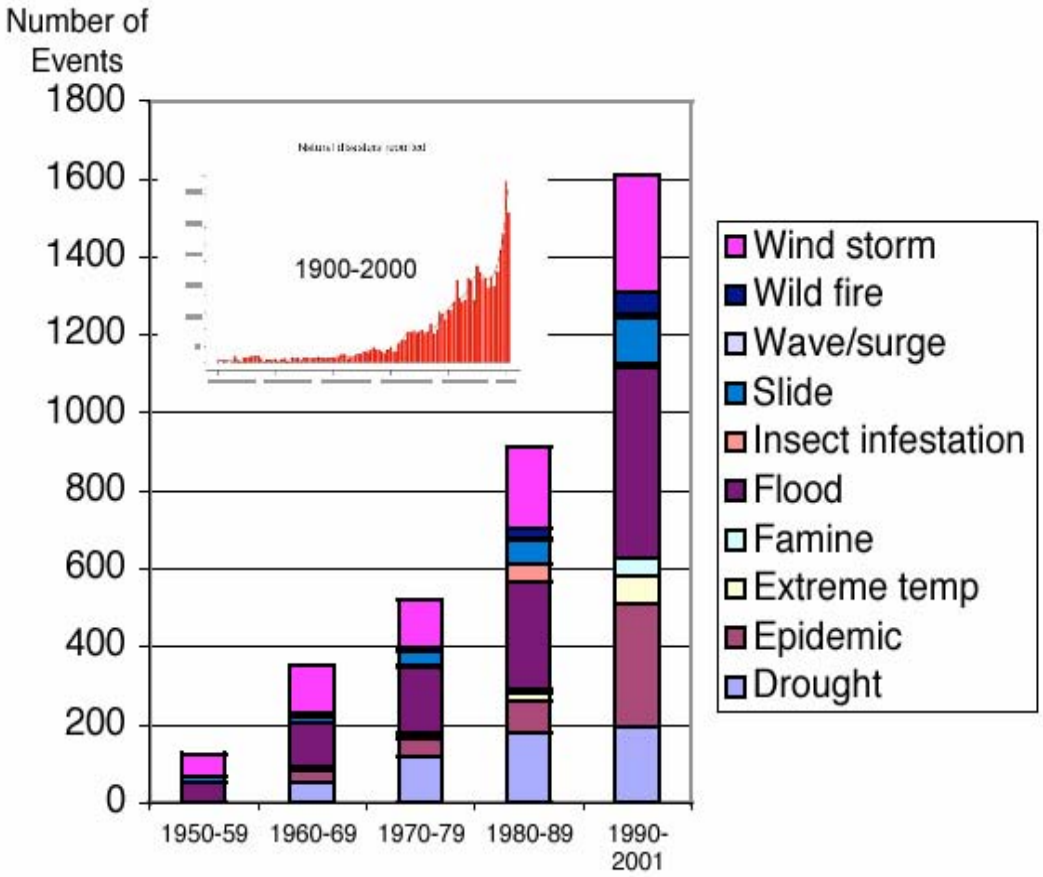
Hurricane Mitch
Impacts On Health and Development

DISEASE CLUSTER

-- *Malaria* (>30,000 cases)
-- *Dengue fever (>1,000)*
-- *Cholera (>30,000)*
-- *Leptospirosis*

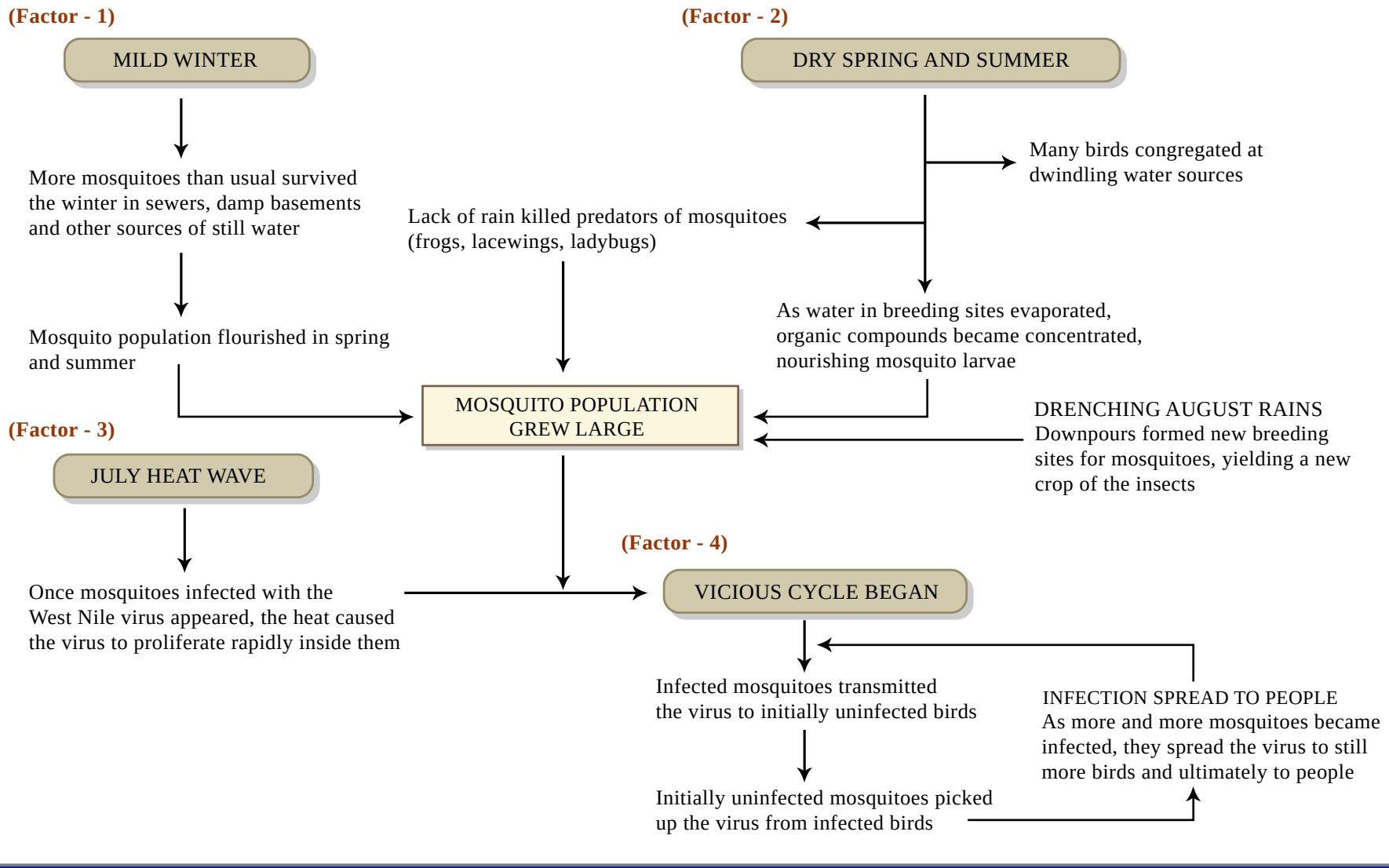
Source: Juan Almendares

Changing Nature and Structure of Events



Sources: OFDA / Center for Research in the Epidemiology of Disasters (CRED) Intl database of Disasters

WNV: Meteorological Factors



WNV: A Disease Of Wildlife

230 SPECIES 44 STATES, DC, 5 CANADIAN PROVINCES

- 138 Bird *spp.*, RAPTORS
  - *37 spp. of mosquitoes*
- HORSES
- ZOO animals
- REPTILES

Ecological Ripples

Infectious Diseases As Forces Of Global Change

↓ Raptors

↑ Rodents

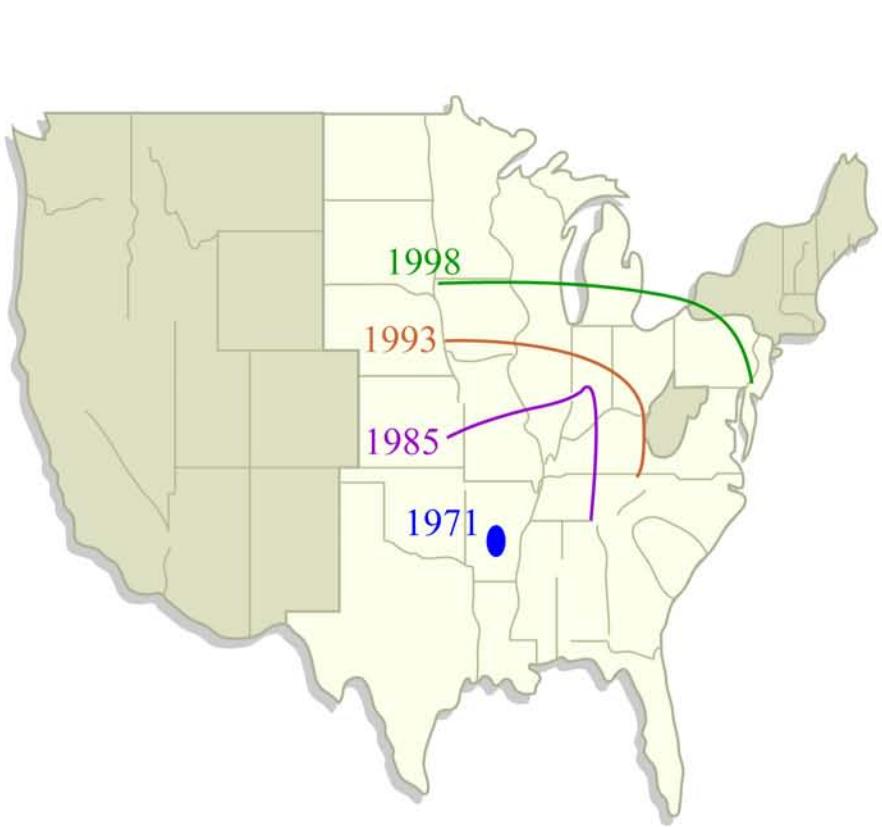
Lyme disease
Hantaviruses
Arenaviruses
Leptospirosis
Toxoplasmosis
Plague

Weather Anomalies, Travel Hazards And Trauma

- Fog, Ice Storms & Road Travel
- Floods & Mudslides
- Ice Instability, Heavy Precipitation & Avalanches
- Infrastructure Damage and Water Q&Q

HEALTH & ECONOMIC IMPACTS

Range Expansion of Soybean Rust



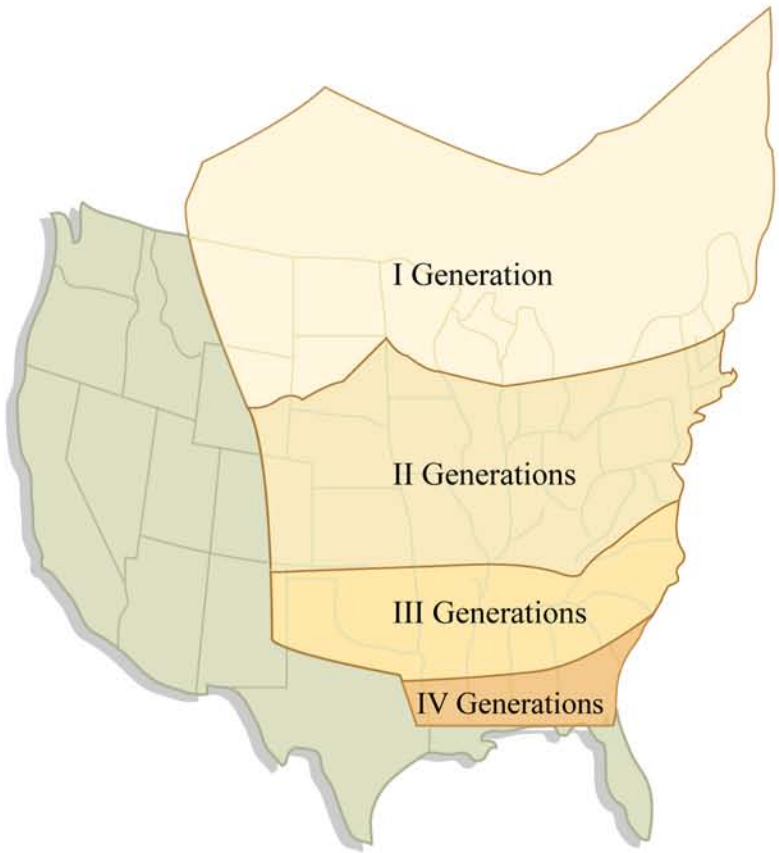


Figure by MIT OCW.

Crop Pests:
Generations/Year

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Drought, Bark Beetles & Fires

Coral Bleaching: Warming and Microbes

Vibrio coralyticus

- lysis at 29ºC
    - release of zooxanthellae
    - infection and immunity

Kushmaro et al., Int J Syst Evol Microbiol 2001; 51:1383

Ray Hayes

Coral diseases

-Patterson *et al.*, *PNAS* 2002;99:872

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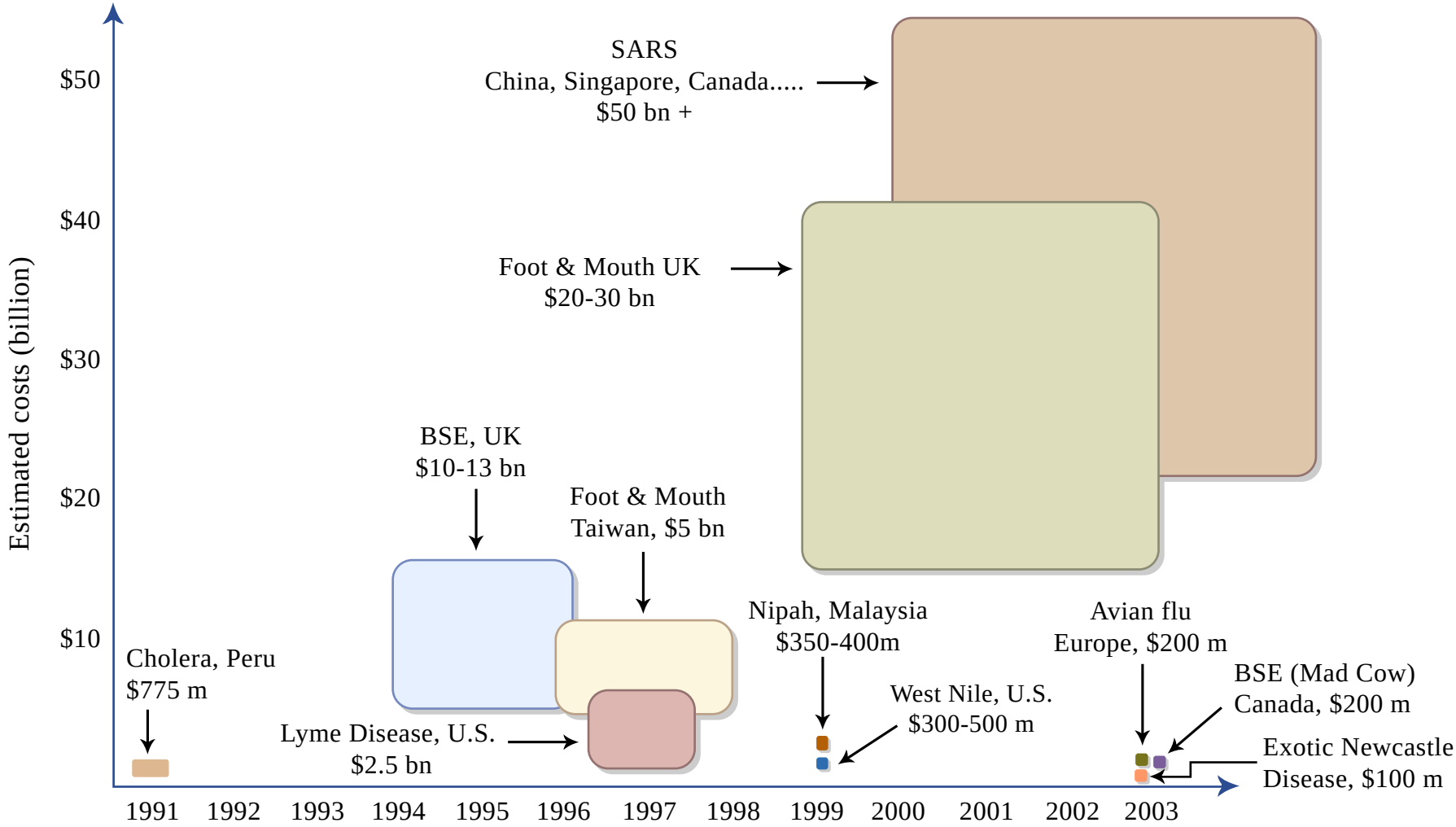
Costs of Emerging Infectious Diseases



Figures are estimates and are presented as relative size.

Uncertainty: Physical → Financial

"Catastrophe insurers can't simply extrapolate past experience."

- Warren Buffett (1992)

Note: plot shows only large events and excludes health/life losses. Including small-scale events would double these numbers; health-related losses unknown

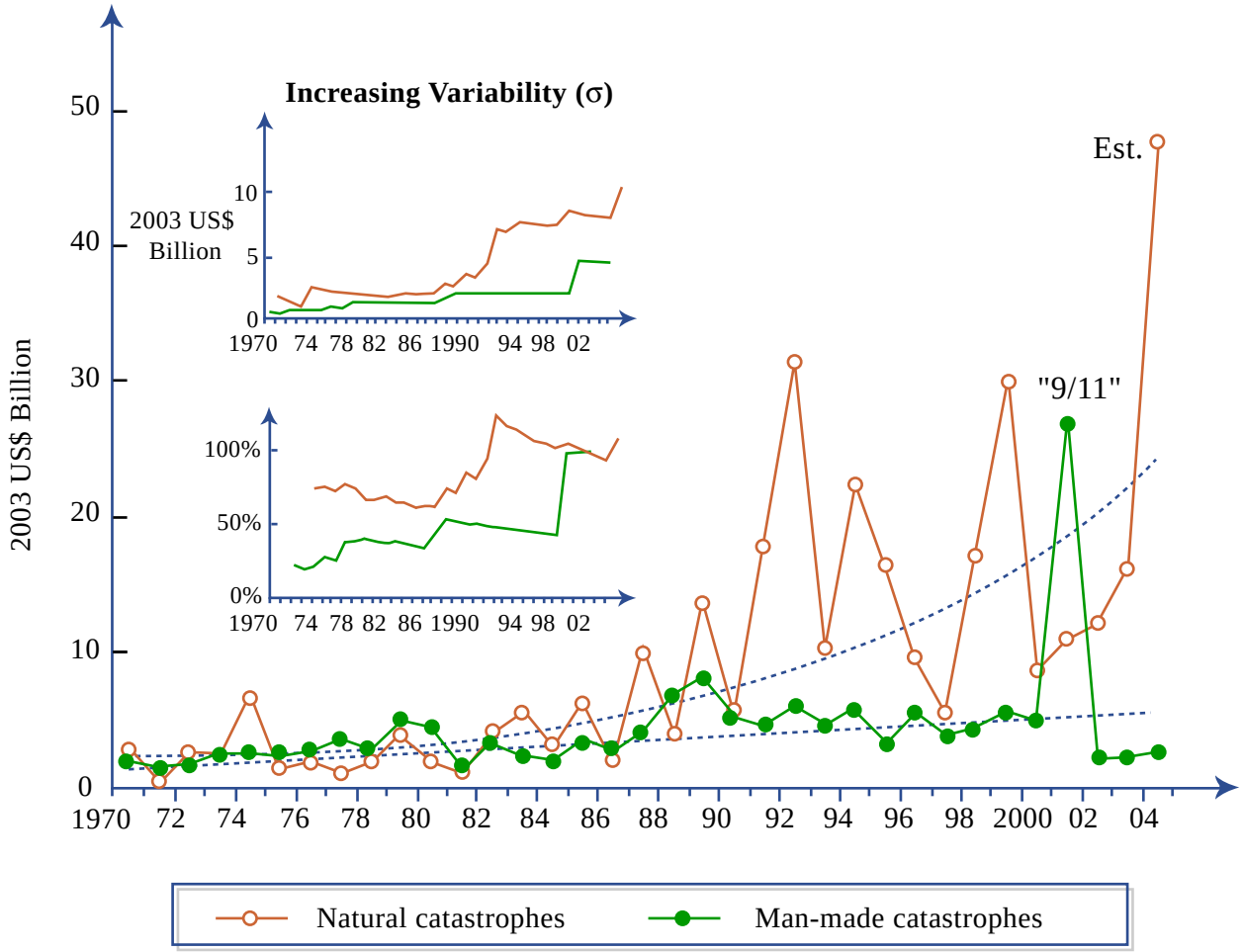


Figure by MIT OCW.

Harmonizing Adaptation with Mitigation

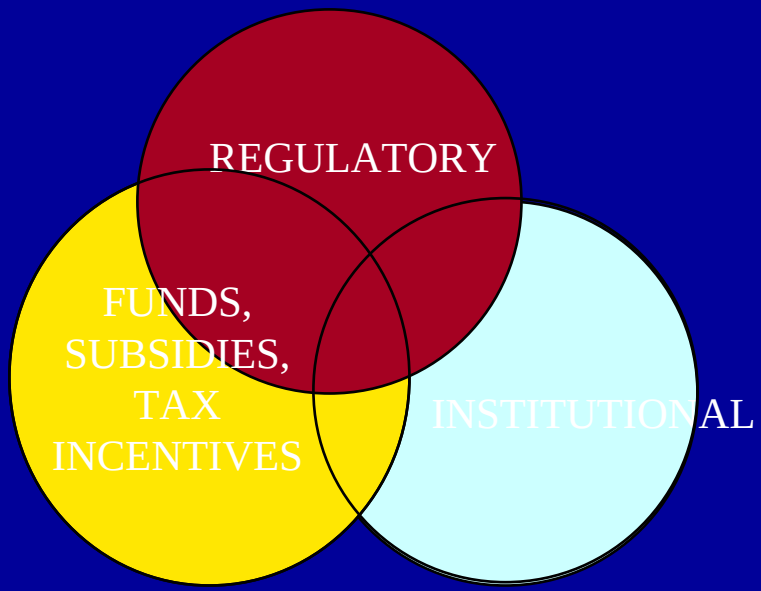
Distributed Generation

Water:

Purification
Pumping
Irrigation
Desalinization

Clinics
Homes
Schools
Computers
Cooking

Enabling Financial Architecture For Sustainable Development



- EE, RE and DG
- "Green Buildings" & Smart Growth
- Rationalized Transport & Transit
- Retrofitting Infrastructure
- Ecological Reconstruction

THE ENGINE OF GROWTH for the 21st CENTURY

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