# The Impact of Climate Change on Human Health in New England[3]

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In the summer of 1997 **skunks** emerged as a problem in many areas of the Northeast. A mild winter, plus habitat loss, plus the die-off of raccoons in previous years due to rabies combined to produce this proliferation. (The skunks replaced the raccoon niche.) Climate, ecological change and disease all interacted to increase the populations of a 'generalist' species that has become a pest. Mild winters are one feature of climate change, and ecological transformations can increase the vulnerability to changes in weather patterns and in the timing of seasons.

Global warming is not a pleasant, nor an easy subject to address. While our understanding of the dynamics of our global systems increases, the uncertainty about it's course and consequences grows. But some changes may already be underway.

Changes in atmospheric chemistry are now altering global physics (i.e., the heat budget). Together with changes in ocean chemistry, biological systems are being affected. Many of the driving forces lie within human social systems, and social policy must reflect the magnitude of the risks.

## SEASONAL CHANGE AND EXTREME WEATHER EVENTS

Spring now comes early to New England; there are now 11 more frost-free days than there were two decades ago.** Recent weather in New England demonstrates how disruptive a more variable and unstable climate—and the associated extreme weather events—can be to biological systems. The prolonged drought in June and July of 1997 was harmful to grasslands, forests and cranberry crops. Rains in August precipitated new crops of mosquitoes, raising the spectra of Eastern equine encephalitis in Massachusetts and Rhode Island.

Elsewhere in the world, Europe experienced its most severe floods in half a century, as North Atlantic sea surface temperatures turned warmer. And North Korea and China were plagued by prolonged drought, spreading famine and infectious diseases. The large El Niño event now evolving in the Pacific portends more severe weather for the coming year.

## A WORD ABOUT EL NIÑO AND GLOBAL WARMING

Several models suggest that El Niño events will increase with global warming (Zebiak & Cane, 1991; Manabe & Stouffer, 1993; Meehl & Washington, 1993; Bengtsson et al., 1993).

Since 1877, El Niño events have occurred on average every 4.2 years. But beginning in the mid 1970s, El Niño-Southern Oscillation (ENSO) events have come more often and persisted longer than in any previous period since 1877 (Trenberth & Hoar, 1996). The 1982/83 El Niño was the largest of the century so far. In March of this year the Southern Oscillation (sea surface pressures) turned negative; and by June, sea surface temperatures (SSTs) along the American coast had developed a 6 degree Centigrade warm anomaly, initiating a strong El Niño for 1997. The increase in El Niño events is consistent with the model projections concerning the effects of climate change on the oceans.

## EMERGING DISEASES

Worldwide there is an emergence of new infectious diseases, a resurgence of old diseases and a redistribution of old diseases, that began in the 1980s and is accelerating in the 1990s. According to The World Health Report 1996: Fighting Disease, Fostering Development of the World Health Organization, 30 new diseases have emerged in the past two decades. There have been other periods in history when infectious diseases have resurged and spread. Often these are periods of accelerated social and environmental change, when growth has outstripped infrastructure.

**OVERHEAD 1 - World Distribution of EIDs**

As you look over this overhead, some diseases - like diphtheria—are transmitted person-to-person. Outbreaks of these diseases primarily reflect changes in social systems and public health infra-

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[3] Note: references to Overheads are made but not included here.

structure. Outbreaks of diseases that involve mosquitoes, ticks and rodents will reflect environmental and climatic factors as well.

Some of the diseases are already appearing at high altitudes, in areas of the world where mountain glaciers are melting at accelerating rates, and where plants are migrating upward. Recent data indicates that freezing levels in the mountains has shifted upward 500 feet or almost 2 degrees Fahrenheit since 1970 (Diaz and Graham, 1996).

## NEW ENGLAND

In New England, several infectious disease are of concern, as ecological and climate change can affect their impact. Eastern equine encephalitis (EEE) involves a complex cycle of mosquitoes, birds, humans and horses. But warm and wet winters, combined with warm and wet summers (or drought punctuated by heavy rains in August) can stimulate mosquito breeding and biting.

**OVERHEAD 2 - EEE risk factors**

*Note the key climatic issues: mild winters and wet springs (Edman et al., 1993).*

**OVERHEAD 3 - Distribution of some Aedes spp. in the U.S.**

Not shown are the Aedes spp. That carry EEE, that are ubiquitous in the continental US. These include Aedes vexans and Aedes sollicitans - the salt marsh mosquito, named for the lawyers on Nantucket that reported it.

Increased surveillance and early warning can reduce the need for extensive spraying of pesticides, harmful to pollinating bees, predator insects and humans.

Another disease of concern in Lyme Disease. The incidence last year was over 16, 000 cases, and increase of 37% over the year before. An estimate 3,500 people on Cape Cod have been infected. Ticks in this region also carry babesiosis (animal malaria), erhlichiosis (a treatable bacterial disease) and a virus (that can cause encephalitis).

The life cycle of ticks is also complex, and involves mice, acorns, deer and humans. But climate plays a role. Unpublished work in Sweden demonstrates that warm, wet winters are associated with heavy crops of ticks two years later, given the two-year development of ticks (Elizabet Lindgren, unpublished data submitted for publication, 1997). (Prolonged droughts, like that of June and July, 1997, can certainly negate this.) If climate change involves warmer winters, in general, more ticks may result; though the increased variability also associated makes linear predictions impossible.

## A WORD ABOUT WINTER AND NIGHTTIME TEMPERATURES

The disproportionate rise in minimum temperatures (winter and nighttime and temperatures or TMINs) (Karl et al., 1993) accompanying climate change is directly bad for human health (e.g., during heatwaves), and favors insect overwintering and activity. Recently, Easterling et al., (1997) report that since 1950, maximum temperatures have risen at a rate of 0.88°C per 100 years, while TMINs increased at a rate of 1.86°C per 100 years. In both hemispheres TMINs increased abruptly in the late 1970s.

Heat-related deaths in cities—which act as heat islands—will be exacerbated by warming. Air pollution and photochemical smog (ground-level ozone) is created both locally and up-wind of urban areas. These impacts, particularly with increased cloudiness, may even act synergistically (e.g., to increases ground-level ozone).

A warmer atmosphere holds more moisture (6% more for every 1°C) (Karl, 1997); and these changes may, in part, be attributable to the increased hydrological cycle (IPCC, 1996; Graham, 1995) and increasing cloudiness, reducing daytime warming and retarding nighttime cooling.

Moreover, the disproportionate rise in minimum temperatures (TMINs or nighttime and winter temperatures) (Karl et al., 1993) accompanying climate change means that less nighttime relief during heat waves, especially when there is a high heat index (a function of temperature and humidity). The humidity traps out-going radiation, decreases nighttime cooling, and exacerbates the impact on mortality.

Infectious diseases may be increased due to climate change conditions (wetter, warmer summers, less severe winters) that promote tick, mosquito and rodent populations, populations which carry diseases such as Lyme Disease, ehrlichiosis, Eastern equine encephalitis, hantavirus, etc.

## HARMFUL ALGAL BLOOMS

Increased run-off of nitrogen and other nutrients into estuaries and bays (from sewage, fertilizers and aerosolized from fossil fuel burning), plus removal of filtering wetlands and reductions in fish that consume algae are all encouraging algal blooms along our coasts. But warm waters and heavy rains (flushing in nutrients) are climatic factors that also promote algal growth.

**OVERHEAD 4—Coastal zone Perturbations**

Note the multiple factors contributing to the reported global increase in the incidence, intensity and persistence of noxious coastal algal blooms.

Hotter summers increase photosynthesis and metabolism of algae, and also favor the more toxic forms—cyanobacteria and dinoflagellates. Thus excess nutrients and warming can lead to increased occurrence of red-tides and shellfish poisoning. Additionally, it can lead to the persistence of brown-tides that lower oxygen levels in water, harm seagrasses and thus shellfish beds. Those off Long Island have crippled the scallop industry. Finally, the affects can cascade through ecosystems and lead to increased diseases of shore birds, sea mammal, fish and humans.

**OVERHEAD 5 - Remote Sensing Image**

SeaWiFs and other remote sensing instruments can now be used to track algal blooms, and help target sampling for toxic species and bacteria - like cholera - that are harbored in the plankton.

**OVERHEAD 6 - Harmful Algal Blooms along the U.S. East Coast**

Data taken from a GIS-based project that can be located on the world wide web at heed.harvard.edu.

**OVERHEAD 7 - Shellfish Toxicity Data in New England States**

A time series of toxic phytoplankton-related events in New England.

## FOOD-BORNE DISEASES

Food-borne diseases such as toxic E. coli, Salmonella, Cyclospora and Hepatitis-A may also be enhanced by warmer, moister conditions. Extreme weather events like flooding are particularly associated with outbreaks of Cryptosporidia and Giardia, protozoa that are not sensitive to chlorine; as flooding flushes these parasite contaminants into clean water systems.

In addition diseases of terrestrial plants and agricultural crops can be affected (Dahlstein & Garcia, 1989; Sutherst, 1990). Extreme weather events (flooding and prolonged droughts) increase the susceptibility of forests to infection. Presently, the woolly adalgid presents a threat to hemlock trees in New England; and stressful weather could exacerbate this problem.

## CLIMATE EXTREMES

Climate extremes are becoming more frequent (Karl et al., 1995), and they are also contribute to outbreaks of disease. Floods foster fungal growth and provide new breeding sites for mosquitoes; while droughts concentrate microorganisms, and encourage aphids, locust, whiteflies and - when interrupted by sudden rains—spur explosions of rodent populations (Epstein & Chikwenhere, 1994). Because of the strong influence of climatic factors prediction of weather patterns based on ENSO and other climatic modes, plus regional patterns, may prove useful for anticipating conditions conducive to such "biological surprises" and epidemics (Bouma et al., 1994; Epstein et al., 1995; Hales et al., 1996).

Does instability indicate increased sensitivity to change, from a further perturbation? Records from this century indicate that periods of warming (from 1900 to 1940, and from mid-1970s to present) were associated with greater variability in heat-degree days, than was the interim period cooling period (1940 to mid 1970s). First, do these multi-decadal shifts follow multi-decadal patterns of convective changes in the oceans (Latif, Barnett, CLIVAR)? Secondly, ice core records indicate enhanced variability may have heralded the state change from the Last Glacial Maximum to the Younger Dryas. Does greater variability, mean greater instability and increased vulnerability to sudden state change—be it to warmer or cooler climate, with smaller or larger polar ice caps?

The oceans are the primary memory for the climate system, absorbing heat and circulating it both laterally and vertically. There is some evidence suggesting that deep ocean warming may be occurring.

Deep ocean warming has been reported from subtropical transects in the Atlantic (Parilla et al., 1994), Pacific Thwaites, 1994) and Indian Oceans (Bindoff and Church, 1992), in the Arctic Tundra and near the poles (Travis, 1994; Regaldo, 1995).

## COSTS

Outbreaks of diseases can affect humans, agricultural crops and livestock; and their impacts can ripple through economies and cascade through societies. In 1991, for example, the cholera epidemic in Latin American cost Peru over $1 billion in seafood exports and lost tourist revenues. In 1994, the outbreak of plague in India (accompanied by malaria and dengue fever in the wake of widespread flooding) cut tourism precipitously and cost international airline and hotel chains from $2 to 5 billion.

Cruise boats are turning away from islands affected by dengue fever and other insect infestations, and coastal algal blooms along beaches. The consequences could be significant: The tourist industry in the Caribbean generates $12 billion annually and employs over 500,000 people.

The current resurgence of infectious diseases involving food, water, insect and rodent carriers can affect trade, transport, tourism and development.

## CONCLUSION

The resurgence of infectious disease in the latter part of the twentieth century may be viewed as symptoms of widespread ecological change. If climate continues to change, its influence on the distribution of infectious diseases may grow. Prudent climate change policies must take into account the magnitude of risk to food security, water security and biological security.

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