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U.S. Environmental Protection Agency
Docket ID No. EPA-HQ-OAR-2025-0194
1200 Pennsylvania Avenue NE
Washington, D.C.

Re: Reconsideration of 2009 Endangerment Finding and Greenhouse Gas Vehicle Standards ("Proposed Rule")

Dear Administrator Zeldin,

Thank you for the opportunity to comment on the Environmental Protection Agency's ("EPA") Proposed Rule.[1]

Our comment focuses on responding to your request for comments on:

> 2. The scientific underpinnings of the Endangerment Finding are weaker than previously believed and contradicted by empirical data, peer-reviewed studies, and scientific developments since 2009 (C-2).

[1] 90 FR 36288 (Aug. 1, 2025).

Table of Contents

Climate Change and Health

Dr. D. Weston Allen, FRACGP, Dr. Jan Breslow, M.D., Dr. Daniel Nebert, M.D.

Introduction

Human health, morbidity, mortality and longevity are significantly impacted by climate. This review examines the evidence for past, present and possible future human health impacts of climate change and its ramifications. It will also examine the health impacts of different energy sources and climate actions. It will not examine every link in the literature to a range of conditions where attribution is implausible or tenuous, or where association assumes causation.

Warmth, Wealth and Health

For over two million years, Earth has been in the grip of an Ice Age interspersed every 100,000 years or so with interglacial warm periods. Our furless species evolved on the hottest continent, probably during the warm Purfleet interglacial,[1,2] spread during the Eemian,[3] also several degrees warmer than now,[4,5] and populated the planet during the present Holocene, dating from 9,700 BCE when South Greenland warmed by 7ºC in just 50 years.[6] Agriculture began and civilizations arose during the Holocene Climatic Optimum[7] which was warmer than now[8] for several millennia in Russia[9] and up to 7ºC warmer in the Arctic.[10]

Humanity flourished and multiplied during the Minoan and Roman warm periods, after which rapid cooling ushered in the dreadful Dark Ages. The bubonic Plague of Justinian (541-542CE) killed 25 million people, 13% of the world's population, and twice that number died from plague over the next two centuries.[11] After flourishing again during the Medieval Warm Period,[12] humanity endured a miserable Little Ice Age (LIA) with frequent widespread crop failures, mass starvation, disease and depopulation.[13] Crop failures over successive summers from 1315 produced the Great Famine of Europe.[14] The *Black Death* of 1346-1353 wiped out 30-60% of Europe's population and up to 200 million people across Eurasia.[15]

Global rewarming since the 18th century, associated with increasing prosperity, better housing, sanitation, food and water supplies, has greatly benefited human health and wealth. Deaths from typhoid and tuberculosis declined dramatically during pre-antibiotic 20th century warming (1910-1945).[16] Mortality from all causes fell as temperatures rose.[17] From a billion people in 1800, the global population doubled by 1927, doubled again to four billion in 1974 and again to 8 billion in 2022. Despite this fourfold increase over the last century, the number of deaths from extreme weather events declined by over 90%.[18]

Northern winters nevertheless remain more lethal than summers,[19] 13% more so in 1952-67 in the U.S. and 16% more so in 1985-90, partly due to the increased availability and affordability of air-conditioning in summer.[20] Climate action in the UK, however, was largely responsible for fuel poverty affecting almost a third of the elderly[21] and high winter death toll in 2017-18, the worst in 42 years despite global warming.[22]

Davis et al (2003)[23] found a 74.4% decline in heat-related mortality in 28 of the largest U.S. cities from 1964 to 1998 and estimated that another 1^{o}C increase would further reduce the net mortality rate.[24] A**nalyzing over 74 million deaths in 384 locations across 13 countries,** Gasparrini et al (2015)[25] found that cold weather was over 17 times more lethal than hot weather: **7.3% of all deaths due to cold and 0.42% from heat.** Masselot et al (2023) found cold weather to be ten times more lethal than hot weather across Europe and forty times more so in northern Europe.**[26]** Their visual display of this difference (Fig. 1) was camouflaged by making the X-axis for heat-related deaths 5.6 times greater than the X-axis for cold-related deaths!

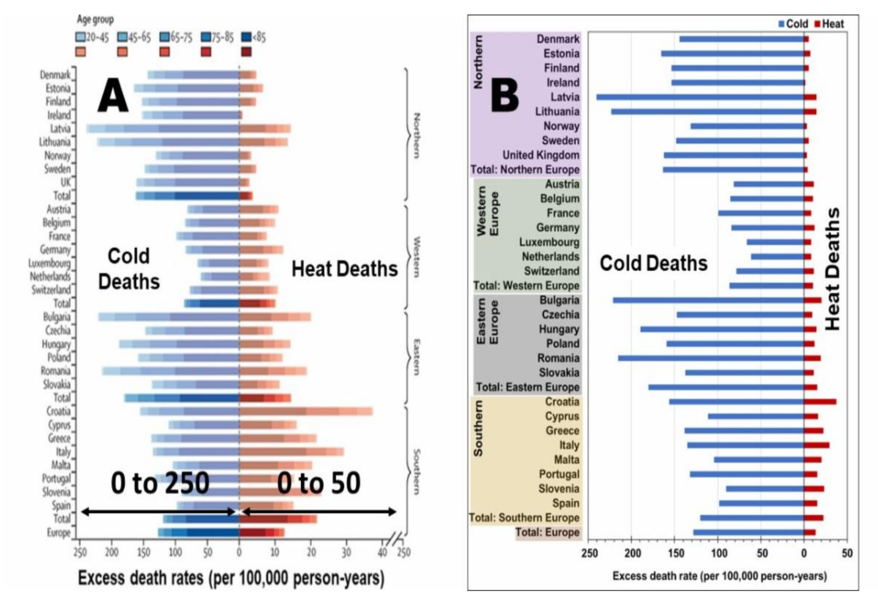

Figure 1: Temperature-related mortality in European cities from Masselot et al. 2023
(A) As depicted in *the Lancet*
(B) Identical X-axis for heat and cold, corrected by the CO_2 Coalition

Life expectancy is strongly associated with wealth or GDP per capita (Fig. 2).[27] Both have been increasing in all regions of a warming world since the Industrial Revolution, the global average life expectancy at birth more than doubling from 32 to 71 years between 1900 and 2021.[28]

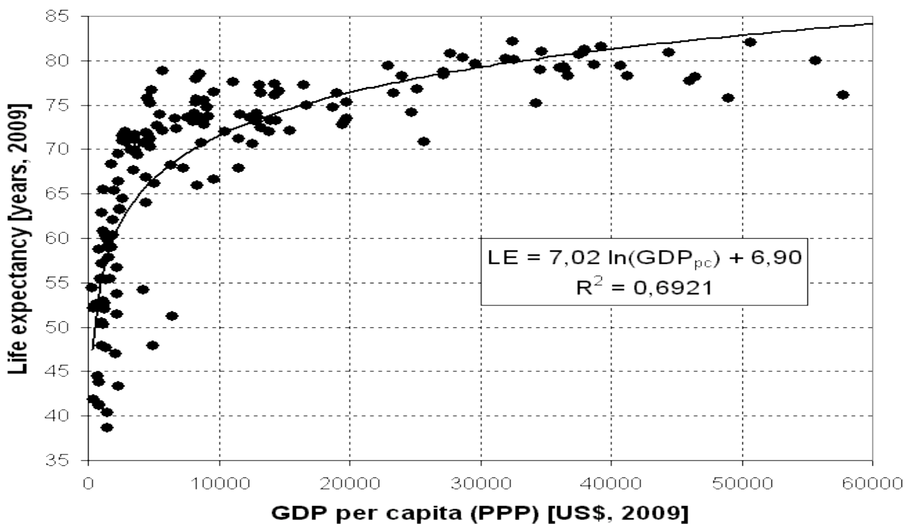

Figure 2: The Preston curve of Life Expectancy at birth increasing with GDP per capita
Source: https://en.wikipedia.org/wiki/Preston_curve

By cheaply and reliably powering industry, mechanizing agriculture and transport, fossil fuels helped to end slavery and emancipate women and children, propelled urbanization, sewerage, safe water supplies, electricity, heating and cooling. They also facilitated better hospitals and health care. Their products and by-products (fertilizers, pesticides and carbon dioxide) also boosted food production and human nutrition.

By how much fossil fuels have contributed to global warming, no one can say precisely, but probably less than earlier estimates.[29] Richard Tol (2010)[30] analyzed fourteen peer-reviewed papers examining the likely impacts on GDP and human welfare of 21st century warming – by 1°C (2 studies), 2.5°C (10 studies) and 3°C (2 studies) – and found that that 1-2°C would probably increase global GDP (Fig. 3). McKitrick (2025)[31] analyzed 1,222 data sets on the impact on crop yields of warming due to increasing CO_2 and found it to be positive up to as much as 5°C of warming.

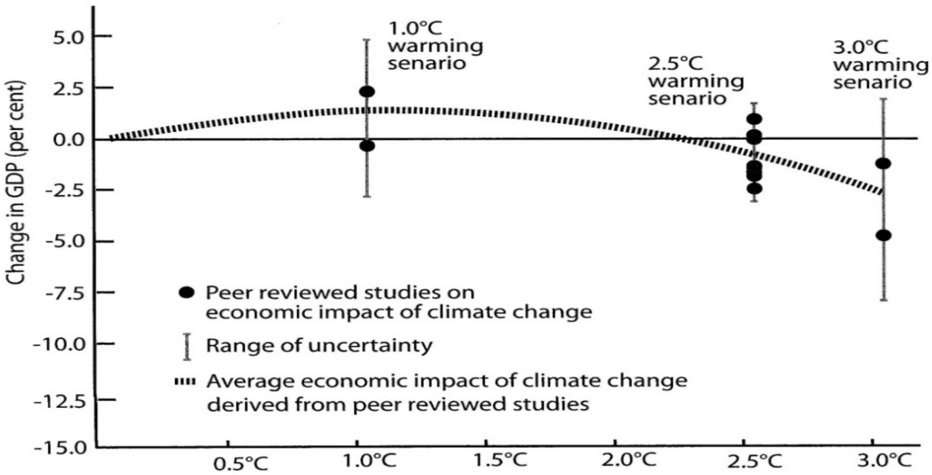

Figure 3: Projected economic impact of global warming of 1°C, 2.5°C and 3°C over the 21st century.
Source: Tol, 2010, derived from UN data

The Lancet confidently predicted in 2009 that climate change would be "the biggest global health threat of the 21st century" but in 1909 who could have predicted two devastating world wars, the atomic bomb, the 1919 influenza pandemic, HIV/AIDS or the global obesity/diabetes epidemic? And who could have predicted the marvels of modern medicine, antibiotics, antivirals, organ transplants, joint replacements, IVF, genetic engineering or a doubling or more of the average lifespan? Prophesies are in the province of religion, not science.

Temperature, Morbidity and Mortality

By absorbing some solar radiation by day and emitting it to earth's surface by night, greenhouse gases reduce the **diurnal temperature range (DTR)**, [32] especially at high latitudes. Whereas solar warming increases daytime maximum temperatures, greenhouse gases primarily impact nocturnal minimums, nicely demonstrated in a study of nighttime temperatures across the U.S.[33] Whereas warming during 1910-1939 was rather even across the year, warming during 1970-1997 impacted primarily the coldest nights (Fig. 4).

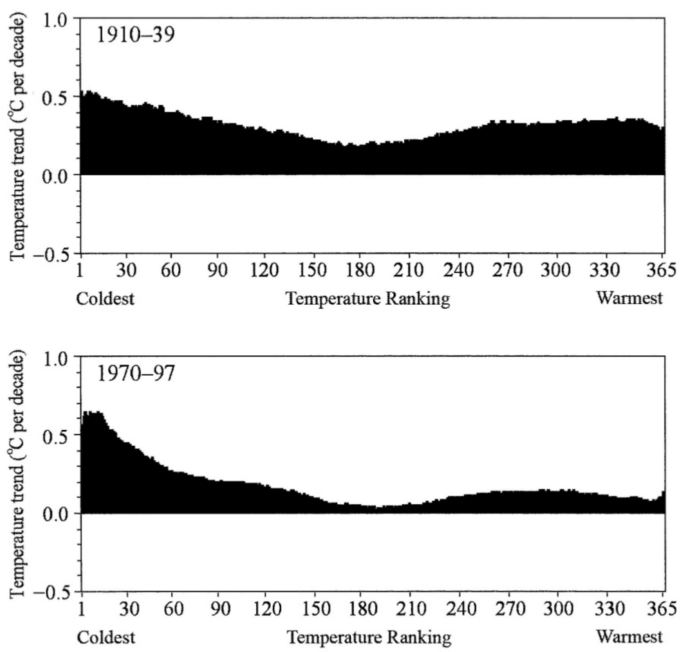

Figure 4: Nocturnal temperature trends for 1910-39 (Top) and 1970-97 (Bottom): trends plotted for the coldest nights from the left (No. 1) to the warmest (No. 365). Source: Knappenberger, Michaels and Davis, 2001

High temperature variability is associated with increased cardiovascular and respiratory mortality in the U.S.[34] Cardiac mortality increased by 1.7% in Hong Kong[35] and by ~3.2% in Shanghai[36] for every 1°C increase in DTR. Emergency visits to the Huashan Hospital (Shanghai) with respiratory infections were 1% and 2% higher for every 1°C increase in the current-day and 2-day moving average DTR respectively. [37] DTR is also a risk factor for chronic obstructive pulmonary disease (COPD) mortality.[38]

The declining DTR,[39] temperature variability[40] and cold nights globally[41] significantly reduce human morbidity and mortality short-term and over time. In a prospective ~5-year study in China, Tang et al (2022)[42] found that the risks for all-cause mortality, cardiovascular disease, and stroke increase by 13% (95% CI: 8–18%), 12% (95% CI: 7–18%), and 9% (95% CI: 2–16%), respectively, per 1 °C increment in DTR. Xu et al. (2013)[43] found that childhood asthma in Brisbane increased for up to 9 days after a DTR above 10°C, with a 31% increase in emergency department admissions per 5°C increment in DTR. His team also found a 1°C increase in DTR to be associated with a 3% increase in Emergency Department Admissions for childhood diarrhea but wrongly concluded: "As climate change continues, DTRs are likely to become more variable. Therefore, the associated health impacts are also likely to increase."[44] When researchers realized that their findings favored climate change, the research dried up!

Cardiovascular disease (CVD) is the major cause of death worldwide. It presents more often in winter and is more often fatal on cold days.[45] A study in the Hunter Region of New South Wales, Australia (1985-1990) found that "fatal coronary events and non-fatal definite myocardial infarction were 20–40% more common in winter and spring than at other times of year"; coronary deaths were up to 40% more likely to occur on cold days than at moderate temperatures.[46] Cardiovascular mortality was 15% higher in the colder months October-March than in April-September in Norway (1990-1995),[47] 33% higher in Californian winters (1985-1996)[48] and 50% higher in mid-winter than in mid-summer in both London (1994-1996)[49] and Israel (1976-1985),[50] despite summer temperatures often exceeding 30ºC.

Braga et al (2002)[34] compared cardiovascular mortality in "hot" cities in the southern United States with "cold" cities in northern states. They found neither hot nor cold weather had much impact in the "hot" cities but significantly increased the mortality in the "cold" cities, where the cold-day effect was five times as great as the hot-day effect and persisted for days. There was a deficit of deaths for a few days after the hot days, indicating that hot days had a "harvesting effect" on those who were about to die. Cagle and Hubbard (2005)[51] examined the relationship between temperature and out-of-hospital cardiac deaths in people over 54 years of age in King County, Washington (USA) over the period 1980-2000; mortality rose by 15% on days with maximum temperatures below 5ºC and dropped by 3% on days with maximum temperatures over 30ºC. In Japan (1970-1999), heart disease and stroke mortality rates were nearly twice as high in winter as in summer. [52]

Stroke is more common in cold weather. Novosibirsk, Siberia has one of the world's highest rates of stroke, 87% being ischemic (due to blocked cerebral blood vessels) and 32% higher on days with low ambient temperature.[53] A similar association was found in Korea, where Hong et al. (2003)[54] found a 24-48-hour lag between exposure to cold and the onset of stroke. A study of World Health Organization (WHO) data on women aged 15-49 from 17 countries in Africa, Asia, Europe, Latin America, and the Caribbean found that a 5ºC reduction in mean air temperature was associated with a 7% increase in hospitalization with stroke.[55] Aneurismal subarachnoid hemorrhage is also strongly correlated with winter and cold weather.[56]

Respiratory disease is strongly related to temperature. Coughs, colds and influenza are far more prevalent in winter. Consultations for respiratory disease in London (1992-1995) increased linearly by 10.5% per degree (below 5ºC).[57] Keatinge and Donaldson (2001)[58] found a linear increase in mortality from respiratory disease in Londoners aged over 50 as the temperature fell below 15°C. The bronchiolitis season in central England was shortened by about three weeks for every 1°C of annual warming from 1981 to 2004.[59] Carder et al. (2005)[60] analyzed non-violent deaths in Scotland (1981-2001) and found that every 1°C drop in the daytime mean temperature below 11°C on any one day was associated with a 4.8% increased respiratory mortality over the following month. Respiratory-related deaths were 47% higher in winter than in summer in Oslo during the period 1990-1995.[47] Even in Sao Paulo, Brazil, Gouveia et al. (2003)[61] found the fewest respiratory deaths in all age groups occurred at 20°C; mortality increased twice as much per degree below 20°C as it did above 20°C.

Asthma increased in many countries by 50% per decade last century[62] and the Centers for Disease Control (CDC) linked this to climate change. [63] Alternative explanations include increasing hygiene,[64] antibiotic use[65] and pasteurization of cow's milk. [66] [67] Although rising CO_2 concentrations and temperatures may increase ragweed pollen numbers,[68] they are highly variable both spatially and temporally.[69] Ragweed pollen has been decreasing in Zurich since 1982, and the major allergenic pollens have been declining in Basel since the early 1990s, as has the incidence of allergic rhinitis (hay fever) in Switzerland.[70] The Poaceae family of herbaceous grasses affects 80% of pollen allergy sufferers in Europe.[71] Jato et al. (2009)[72] found that the Poaceae pollen count had declined in four Spanish cities since 1993, by ~75% in Lugo and by 80% in Santiago. They also found a delayed onset and shorter duration of the atmospheric pollen season.

Eczema prevalence in the U.S. is significantly lower when the temperature and relative humidity are highest.[73] A study of atopic eczema in the mountainous area of Davos, Switzerland in 1983–1989 found itch-intensity to be inversely correlated with temperature.[74] Thirty Norwegian children improved in severity of eczema, quality of life, skin bacterial culture and medication usage after spending a month in the Canary Islands, and the improvement compared to a matched control group was still apparent three months later.[75]

Cholera, which afflicts 3-5 million people and kills about 100,000 annually,[76] is now confined to developing countries in the tropics and subtropics (Fig. 5). When an epidemic broke out in London in 1848, Dr. John Snow performed the world's first epidemiological studies in linking it to contaminated water. Nearly a century and a half later, a paper in the prestigious journal *Science*[77] linked a 1991 outbreak in South America to climate change. The real cause, however, was a failure of the Peruvian authorities to properly chlorinate water supplies.[78] Climate change can be a convenient scapegoat for government failure!

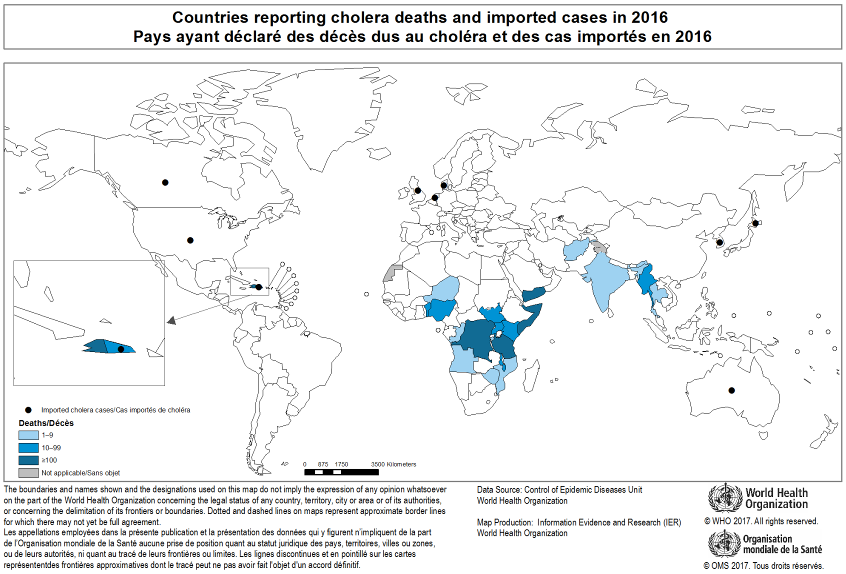

Figure 5: Distribution of cholera in 2016 as reported to the World Health Organisation.
Source: http://gamapserver.who.int/mapLibrary/Files/Maps/Global_Cholera(WER)_2016.png

Gastroenteritis, which kills around 444,000 children every year globally,[79] is predicted to increase with climate change[80] from enteroviruses released in glacial melt[81] and more bacteria in warmer seas and flood water.[82] Rotavirus and norovirus, the most common pathogens causing diarrhea in children and adults respectively, survive less well at warmer temperatures however.[83] Moreover, ED admissions for childhood diarrhea decline as DTR declines with climate change.[45] Infectious disease accounted for 74% of infant deaths in the UK[84] before the motor vehicle saved cities from drowning in fly-breeding horse dung, the reason for the first international urban planning conference in 1898. Waste removal, fly control, clean water reticulation, the heating and refrigeration of food reduced diarrheal disease dramatically in the developed world. The question is whether depriving developing countries of cheap reliable energy for such proven preventive measures to reduce global emissions will save more lives than it loses.

Future Warming

Predictions are notoriously difficult and uncertain. Modelled mortality risks based on modelled climate changes based on modelled emissions scenarios are prone to so many biases and errors that they should be regarded as mere guesstimates. Keatinge and Donaldson (2004)[85] postulated that “the overall effect of global warming on health can be expected to be a beneficial one.” Evaluating the future impact of unchecked global warming on human health, Bosello, Roson and Tol (2006)[86] projected 1.4 million fewer deaths annually to 2050 and a lower mortality rate until at least 2200. More recently, Gasparrini et al. (2017)[87] projected unmitigated heat-related mortality to soon overtake cold-related mortality in SE Asia regardless of emissions scenario used, but not in Australia or North America until the end of this century and then only with the highest and most unlikely[88] emissions scenario (RCP8.5 = 1,370ppm CO_2 equivalent) and warming (4.9°C). Using the more realistic RCP4.5 scenario (650ppm CO_2 equivalent and 2.4°C of warming), cold remains more lethal than heat in all regions studied except SE Asia and South America (Fig. 6). The best fit with the global climate trend of 0.16°C/decade in the satellite data since 1978[89] is the RPC2.6 scenario.

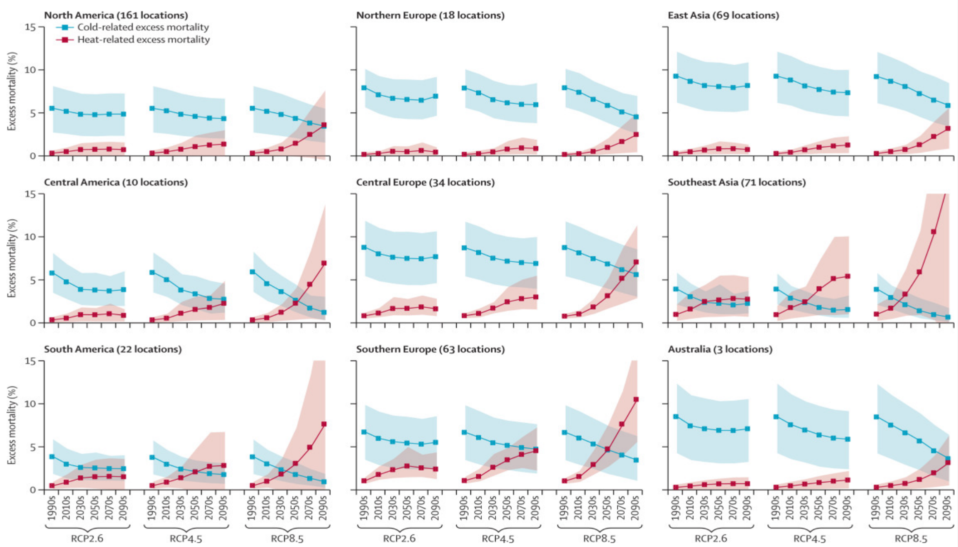

Figure 6: Projected changes in cold-related and heat-related excess mortality over the 21st century for nine regions and three emissions scenarios: RCP2.6, RCP4.5 and RCP8.5

Alaska, Africa, the Middle East, northern and central Asia, India, Indonesia and Russia were not included. **Adaptation and demographic changes** were also ignored. The authors warned: “The reported figures should therefore be interpreted as potential impacts under well-defined but hypothetical scenarios, and not as predictions of future excess mortality.” When Christidis et al. (2010) [90] factored **adaptation** into an analysis of the benefit of global warming on the mortality rate in England and Wales during the period 1976-2005, they found the lives-saved to lives-lost ratio increased fourfold to 121.4. A projection that ignores adaptation can safely be ignored.

Demographic changes also favor warmth. So many U.S. citizens move from the cold northeast states to warm southern states that it is thought to have contributed 3-7% of the late 20th century gains in longevity and delay about 4,600 deaths annually.[91]. We don't see Singaporeans, Malaysians or Indonesians fleeing the heat. Overpopulation, poverty, religious/tribal conflicts, political instability and corruption dwarf climate change in driving migration. [92] Fertility rates tend to fall as countries become wealthier and carbon emissions per capita increase.

Temperature Extremes

Deadly heatwaves such as the European one in 2003 are often attributed to climate change.[93] Temperatures elsewhere across the globe at the time, however, were normal or below normal (Fig. 7).[94]

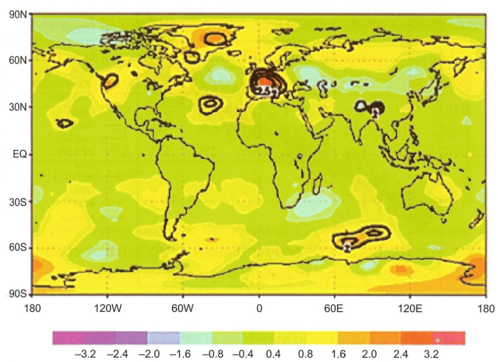

Figure 7: Global tropospheric temperature anomalies, June-August 2003.
Source: Chase et al. (2006)

Australia's deadliest heatwave,[95] with temperatures of 102°F (38.9°C) or above for 24 days straight, 120°F (49.9°C) in the shade at Bourke, and 109°F (42.8°C) at midnight at Brewarrina, was in January **1896**.[96] Seven months later, the eastern United States had a 10-day heatwave that killed nearly 1,500 people.[97] Another very prolonged heatwave there in 1901 killed 9,500 people, making it easily the most destructive heatwave in U.S. history.[98] The 1936 North American heatwave during the Dust Bowl decade set record temperatures across 14 states, reaching 49°C in Steele, North Dakota, and killed at least 5,000 people.[99] The 1954 summer-long heatwave across the Midwest, reaching 117°F (47.2°C) in East St Louis, ranks as the hottest in 11 states (Fig. 8) based on an analysis of Midwest temperature records from 1845 to 2009.[100] Nancy Westcott (2011) also found a *reducing* trend of heatwaves over the 20th century.

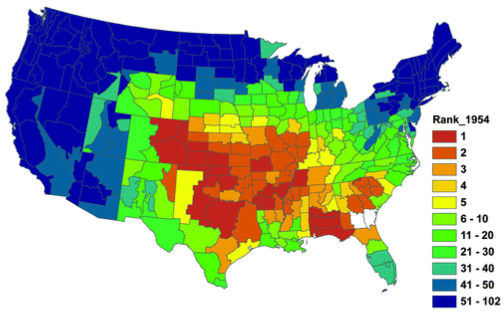

Figure 8: Rank of the June–September 1954 heat wave based on National Climatic Data Center (NCDC) climate division temperature data for the years 1895–2009. Source: Westcott (2011)

The fourth National Climate Assessment (NCA4) states: "Heat waves (6-day periods with a maximum temperature above the 90th percentile for 1961–1990) increased in frequency until the mid-1930s, became considerably less common through the mid-1960s, and increased in frequency again thereafter. As with warm daily temperatures, heat wave magnitude reached a maximum in the 1930s"[101] (Fig. 9). A 1915-2025 analysis of U.S. heatwaves by region reveals that heatwaves in the first half of the 20th century were primarily in the eastern two-thirds and primarily in the West since 1990.[102] The frequency and severity of both extreme heat and extreme cold in the U.S. have declined since 1898.[103]

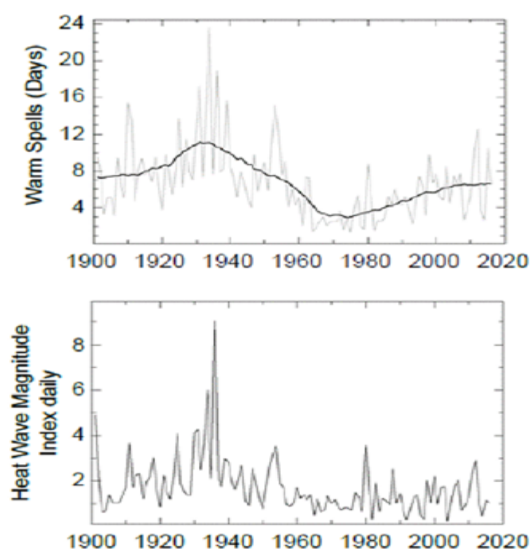

Figure 9: U.S. Heatwaves since 1900.
Source: NCA4 Figure 6.4

Urban heat intensifies heatwaves and heatwave mortality much more than does global warming.[104] Cities can be over 11°C hotter than the surrounding countryside; the larger the city the greater the difference.[105] The percentage of the global population classed as urban increased from 30% in 1950 to 50% in 2008 and is expected to reach 70% by 2050.[106] The U.S. population is now nearly 90% urban. Unlike global warming, urban heat can be effectively and efficiently mitigated,[107] creating cool city refuges[108]using greenery and water features, requiring careful urban planning and adequate water resources.

Air pollution also exacerbates heatwave mortality. Of the estimated excess deaths attributed to unusually high temperatures during the 2003 European summer,[109] elevated atmospheric concentrations of ozone and particulate matter less than 10µm diameter (PM_{10}) accounted for 21-38% in the UK[110] and 33-50% in the Netherlands.[111] Mortality was also higher than expected from temperature alone in France.[112] The EU's decision in 2001 to promote diesel to reduce CO_2 emissions probably increased heatwave mortality!

Obesity, now an epidemic,[113] exacerbates heatwave mortality by reducing heat-tolerance[114] while aerobic fitness increases it.[115] Acclimatization reduces mortality from heatwaves but not cold waves.[116] Whereas mortality from the latter remains higher for weeks, it drops rapidly and dramatically after heatwaves, indicating that most of those who die were close to death anyway.[117] This *harvesting effect* found in the U.S. and Europe[118] results in "virtually no lasting impact of heat waves on mortality."[119]

Affordable energy reduces heatwave mortality. The 1954 Midwest heatwave was worse than the 1936 heatwave in intensity, extent and duration, but killed fewer than a fifth as many people,[120] largely because air conditioners, electric fans, refrigerators, ice and cold drinks had become available and affordable.

Heatwave planning. Following the 2003 European heatwave, which caused 15,000 excess deaths during France's August vacation with its relative lack of care for the isolated and vulnerable, the French Directorate General for Health set up a National Heat Wave Plan. This included a system for real-time surveillance, prevention and treatment of heat-related diseases, air-conditioning equipment for hospitals and retirement homes, city-scale censuses of the isolated and vulnerable, visits to them during the alert periods, a warning system and preventive message broadcasting by the media. When France experienced another severe heatwave in July 2006, there were nearly 4,400 fewer deaths than expected. Modern forecast and warning systems have also been shown to be very effective in preventing heat-related deaths.[121] Lazy governments blame climate change instead of implementing effective heatwave mortality-reduction measures.

Temperature and Disease Vectors

Vector-borne infection is regarded by the IPCC as a major climate change challenge to human health.[122] The World Health Organization (WHO) states that vector-borne diseases account for over 17% of all infectious diseases and causes more than 700,000 deaths annually. [123] It is postulated that global warming will spread the following disease vectors to areas that have hitherto been too cool for them.[124]

Vector	Species	Diseases
Mosquitoes	*Anopheles*	Malaria – *P. falciparum, P. vivax, P. ovale and P. malariae*
	Aedes	Chikangunya, Dengue, Yellow Fever, Ziga
	Culex	West Nile Virus
Ticks	*Ixodes*	Lyme disease
Sandflies		Leishmaniasis

Malaria was endemic for millennia in Europe and England[125] where 17th century burial records reveal a mortality rate comparable to that in sub-Saharan Africa today.[126] Apart from epidemics during the unusually hot summers of 1848 and 1859, there was a near-linear decline in endemic malaria in the UK from 1840 to 1910. It disappeared in 1953 and re-establishment is considered highly unlikely regardless of warming.[127] Endemic malaria in Finland likewise faded out over two centuries of warming with limited or no counter measures or medication, leading Hulden and Hulden (2009) [128] to conclude that, “malaria in Finland basically was a sociological disease and that malaria trends were strongly linked to changes in the human household size and housing standard.” Helsinki had its last malaria epidemic in 1902. Devastating epidemics occurred in parts of northern Europe, even in the Arctic Circle, until the middle of the 20th century.[129] In the U.S., a malaria epidemic affected 30% of the population of the Tennessee River Valley in 1933.[130] Despite rapid warming from 1916 to 1937, there was a four-fold decline in deaths from malaria in Mississippi; the only significant correlation was with family income: the higher the income the fewer the deaths.[131] Malaria remained endemic in 36 states until the CDC was created to tackle it after World War II. Swamps were drained, agricultural practices were changed, cases were isolated from mosquitoes and treated, mosquito nets and DDT were widely used, millions of homes were sprayed, and the U.S. was considered malaria-free in 1951.[132] Despite global warming, the 20th century saw a dramatic decline globally in both endemicity[133] and per capita mortality rate (down 95.4%).[134]

Studies extending over 10-32 years found no correlation between temperature or rainfall and the incidence of malaria in western Africa,[135] at four highland sites in east Africa[136] or in western

Kenya.[137] A comprehensive study across Africa over an 85-year period (1911-1995) found a correlation with precipitation in Southern Mozambique but none with temperature anywhere.[138] In a review paper, Rogers and Randolph (2006)[139] attribute the observed increase in malaria in many parts of Africa it to "land-cover and land-use changes and, most importantly, drug resistance rather than any effect of climate," noting "the recrudescence of malaria in the tea estates near Kericho, Kenya, in East Africa, where temperature has not changed significantly, shows all the signs of a disease that has escaped drug control following the evolution of chloroquine resistance by the malarial parasite."

Haque *et al*. (2010)[140] analyzed monthly malaria case data for the malaria endemic district of Chittagong Hill Tracts in Bangladesh from January 1989 to December 2008. They found no correlation with temperature, rainfall or humidity, but a strong negative association with the normalized difference vegetation index (NDVI), a satellite-derived measure of surface vegetation greenness. They state: "each 0.1 increase in monthly NDVI was associated with a 30.4% decrease in malaria cases" probably due to increasing insectivorous bird populations. By stimulating plant growth, CO_2 may be reducing malaria risk.

It is thought that global warming will allow malaria to climb to higher altitudes.[141] Before the introduction of DDT and other public health measures, however, malaria transmission occurred much higher than now, at up to 2,600m in Kenya, 2,450m in Ethiopia, 2,500m in the Himalayas, 2,180m in Argentina and 2,773m (near thermal springs) in Bolivia.[142] After considering forest clearance, agriculture, urbanization, health infrastructure, drug and insecticide resistance, civil strife and other influences on endemic malaria in the Highlands of Kenya and New Guinea, Paul Reiter of the Insects and Infectious Disease Unit of the Institut Pasteur in Paris, France concluded that "simplistic reasoning on the future prevalence of malaria is ill-founded; malaria is not limited by climate in most temperate regions, nor in the tropics, and in nearly all cases, 'new' malaria at high altitudes is well below the maximum altitudinal limits for transmission."

The impact of climate change on future global malaria distribution proved to be much weaker when GDP per capita was included in the models.[143] One model using five variables and a high-emissions scenario actually produced a 0.92% decrease.[89] Indur Goklany (2004)[144] calculated that the malaria death toll could be halved through a combination of proven measures costing a tiny fraction of mitigation costs.

Chikungunya virus (CHIKV) was first isolated in Tanzania during an outbreak of incapacitating arthralgia in 1953.[145] The African primary hosts are non-human primates and small mammals, and *Aedes aegypti* is its primary vector. CHIKV has been spreading rapidly in recent decades but not due to climate change. *A. aegypti* had escaped Africa centuries ago with the slave trade and established itself widely across tropical and subtropical regions (Fig. 10), even in southern Europe before disappearing there in the mid-1990s.[146]

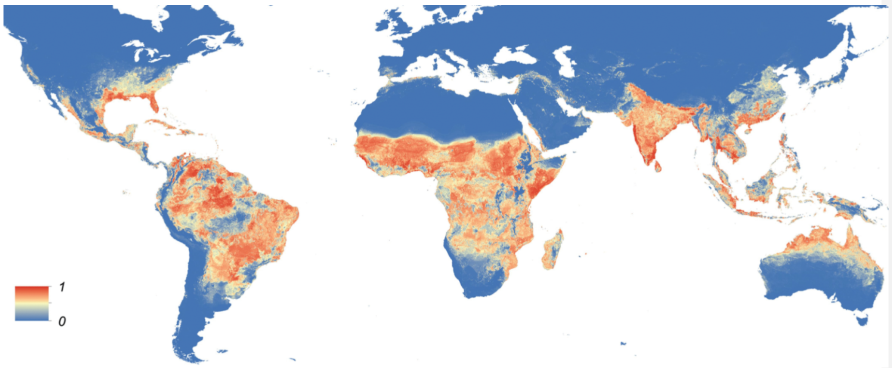

Figure 10: Global distribution of *Aedes aegypti*: probability from 0 blue to 1 red.
Source: Kraemer et al 2015[147]

CHIKV broke out on Reunion Island and neighboring Indian Ocean islands in 2005 and in India in 2006. It then spread to South-East Asia,[148] simultaneously undergoing a genomic micro-evolution which enabled it to be transmitted by *Aedes albopictus*, the tiger mosquito of SE Asia.[149] *A. albopictus*, which is intolerant to extreme heat,[150] has been adapting to cold climates in temperate regions such as Japan. It can hibernate over winter and produce eggs that are more cold-tolerant.[151] Adult mosquitoes can even survive freezing winters in suitable microhabitats.[152] It spread to Albania in 1979[153] and to Genoa, Italy in imported used tyres in 1990.[154] By 2007, it had spread extensively across southern Europe (Fig. 11). Ravenna in northern Italy experienced Europe's first CHIKV epidemic after the virus was introduced from India.[155] *A. albopictus* has recently spread westward in the continental United States, where locally acquired cases occurred in 2014,[156] but only travel-associated cases have been reported since 2015.[157]

Modelling by Fischer et al. (2013)[158] projected an increased risk "for Western Europe (e.g. France and Benelux-States) in the first half of the 21st century and from mid-century onwards for central parts of Europe (e.g. Germany). Interestingly, the southernmost parts of Europe do not generally provide suitable conditions in these projections." In other words, their emissions scenarios will make it too warm for *A. albopictus* to remain established in southern Europe.

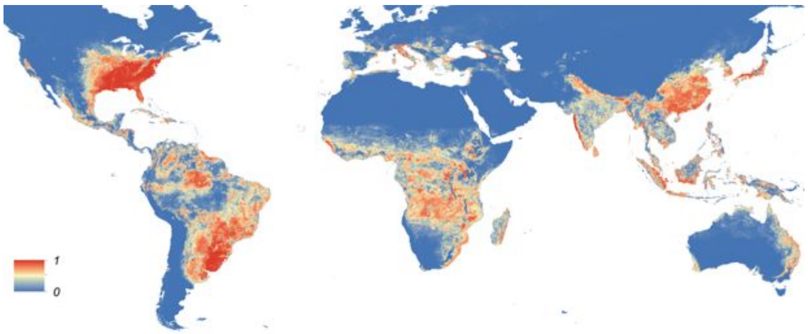

Figure 11: G[lobal distribution] of *Aedes albopictus*: probability of occurrence from 0 blue to 1 red. Source: Kraemer et al 2015[147]

The reality, of course, is that no one knows what might happen this century; warming may be less than thought, vaccines and public health measures may control or even eradicate the virus from the developed world, it may mutate again, or more CO_2 may even reduce the incidence. Tuchman *et al*. (2003)[159] grew the quaking aspen (*Populus tremuloides*) (Michaux) trees at atmospheric CO_2 concentrations of either 360 ppm or 720 ppm for an entire growing season and fed the incubated leaf litter to four species of mosquito larvae to assess the effect on development. They found the larvae of *Aedes albopictus* had a mortality rate 2.2 times higher when fed the high-CO_2 litter, which delayed the development of all larvae by 9-20 days.

Dengue fever is arguably the most important vector-borne viral disease globally, infecting over 200 million people, 1% of them severely with over 20 thousand deaths annually.[160, 161, 162] A review of 16 studies, carefully selected from 75 papers with methodologies of varying quality, found dengue transmission to be highly sensitive to climatic conditions, especially temperature, rainfall and relative humidity.[163] Climate change is implicated by the following: incidence increasing 30-fold over the past 5-6 decades; endemicity increasing to involve 119 countries; expanding transmission zone to include half the world's population; lengthening mosquito lifespan and shortening virus incubation period with warming, resulting in more infected mosquitoes over longer periods. [164] This must be weighed against other historical facts, scientific evidence, research and developments:

- Dengue and yellow fever were major public health problems in the U.S. during the cold 17th century but disappeared during the warm 20th century.[165] The CDC states: "As recently as the 1940s, large dengue outbreaks were documented in the United States reaching places as far north as Boston. Today, the situation has changed significantly. Reasonable climate, competent mosquito vectors, and susceptible human hosts are all still present in the continental United States, and dengue viruses are frequently reintroduced by infected travelers.[166] Transmission in the U.S. is rare, however, because there is insufficient contact between infected humans, vector mosquito species, and susceptible humans to sustain transmission."

- Alternative explanations for the observed global increase in incidence include rapid urbanisation, international travel and disruption of vector control programs.[161] The authors conclude: "Population dynamics and viral evolution offer the most parsimonious explanation for the observed epidemic cycles of the disease, far more than climatic factors." In 1995, dengue afflicted over 4,000 Mexicans in Tamaulipas while Texas had only a handful of non-imported cases. The essential difference was not climate but living standards and sound public health policies.[167] Laredo, Texas, (population 200,000) and Nuevo Laredo, Tamaulipas, (population 290,000) are connected by bridges across the Rio Grande. After an outbreak in 1999, Reiter et al. (2003)[168] found "the incidence of recent cases, indicated by immunoglobulin M antibody serosurvey, was [12.3 times] higher in Nuevo Laredo, although the vector, *Aedes aegypti*, was more abundant in Laredo." Reiter *et al.* determined that "the proportion of dengue infections attributable to lack of air-conditioning in Nuevo Laredo was 55% ... [and] if the current warming trend in world climates continues, air-conditioning may become even more prevalent in the United States, in which case, the probability of dengue transmission will likely decrease." The CDC endorsed this: "Studies on the U.S.-Mexico border, for example, suggest that the restriction of transmission there is due to the limitation of contact between human hosts and mosquito vectors that comes with low housing density and the use of air conditioning and screens." [169]
- Future solutions to dengue could include the development of effective dengue vaccines, genetic modification of A. aegypti,[170] the sterile insect technique[171] (shown to reduce the target mosquito population by more than 90%) and the *Wolbachia* bacterium,[172] which allows mosquitoes to be resistant to arboviruses such as dengue and Zika.

West Nile Virus (WNV) was first identified in a West Nile district of Uganda in 1937. It is asymptomatic in 80% of infected people but can cause severe encephalitis or meningitis in about 1 in 150 infected persons, especially the elderly or immunocompromised. It is transmitted by a *Culex* species of mosquito that has bitten an infected bird (not human). Appearing in New York in 1999 and spreading across the states taking hundreds of lives, it was soon linked to climate change. [173] [174] But its rapid spread from northeast to the south and west (Fig. 12) and its decline despite warming (Figs. 13 and 14) indicates that the vector was already there and climate change had nothing to do with that.

Figure 12: Progress of WNV in the U.S. 1999-2003. White 0, Blue <1%, Green1-5%, Yellow 5-10%, Red >10%

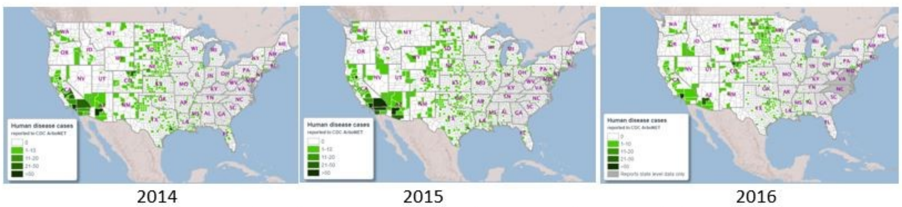

Figure 13: WNV cases reported to the CDC 2014-2016. White 0, Green light 1-10, dark 21-50, Black >50

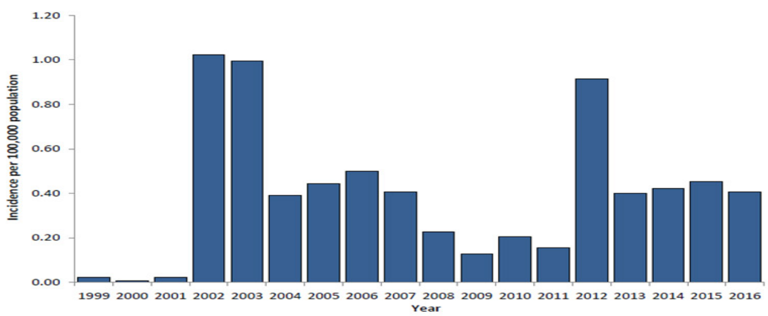

Figure 14: West Nile virus neuro-invasive disease incidence reported to CDC by year, 1999-2016
Source of Figs 9-11: CDC Cumulative Maps and Data[175] and Wikipedia[176]

Yellow fever spread from Africa to the Americas and Caribbean via the slave trade. The first recorded outbreak was in 1647 on the island of Barbados.[177] It reached New York City in 1668 and Philadelphia a year later; a 1793 epidemic in Philadelphia[178] wiped out nearly 10% of its population.[179] Major outbreaks hit New Orleans in 1833 and 1853, and Memphis in 1878.[180] It spread to Europe early in the 19th century and took the lives of thousands in Gibraltar[181] and Barcelona.[182] There were even small outbreaks in France[183] and Wales.[184] Thanks to an effective vaccine[185] and stringent travel regulations, it is now confined to central Africa and South America. The story of yellow fever illustrates that the answer to vector-born disease is not climate action but sound science and public health policies.

Zika virus was first identified in the 1960s in South-East Asia, where it produced nothing more than a mild illness: fever, rash and aching joints. In 2013, a Zika strain suddenly appeared in French Polynesia, then in the Caribbean and Brazil, where it exploded and resulted in over 4,000 cases of microcephaly between late 2015 and early 2016. By September 2017, there were thought to have been between three and four million cases of Zika across 84 countries due to international air travel. A Singaporean outbreak that began in August 2016 resulted in 455 cases over three months. When Singapore's Ministry of Health and National Environment Agency quickly identified and managed infected people, eradicated mosquitoes and removed breeding sites, new cases were reduced by 48% within a month.[186] Public health measures can control such outbreaks before climate mitigation gets its boots on! Climate action which impedes proven preventive measures is actually counterproductive.

Lyme disease was first diagnosed in 1975 in Old Lyme, Connecticut,[187] from whence it derived its name. It is the most common tick-borne human disease, with an estimated annual incidence of 300,000 in the United States[188] and at least 85,000 in Europe.[189] It is caused by the spirochete bacteria, *Borrelia burgdorferi* and sometimes by *Borrelia mayonii*.[190] It is transmitted in the eastern United States and parts of Canada by the tick, *Ixodes scapularis,* and on the Pacific Coast by *I. pacificus.*[191] As these ticks like habitats with at least 85% humidity and need temperatures over 7 °C (45 °F) during host questing in spring,[192] the northeast United States is especially suitable (Fig. 15).

The impact of climate change on Lyme disease appears to be complex. Subak (2003)[193] found a correlation between warmer winters and the incidence of Lyme disease the next summer, perhaps because mild winters enhance survival of the ticks' primary host, the white-footed mouse. Warm dry summers, on the other hand, are associated with a reduced incidence, perhaps because of reduced survival of both mouse and *Ixodes* nymph.[194] The number of reported cases of Lyme disease appears to have peaked in 2009, despite further warming (Fig. 16).

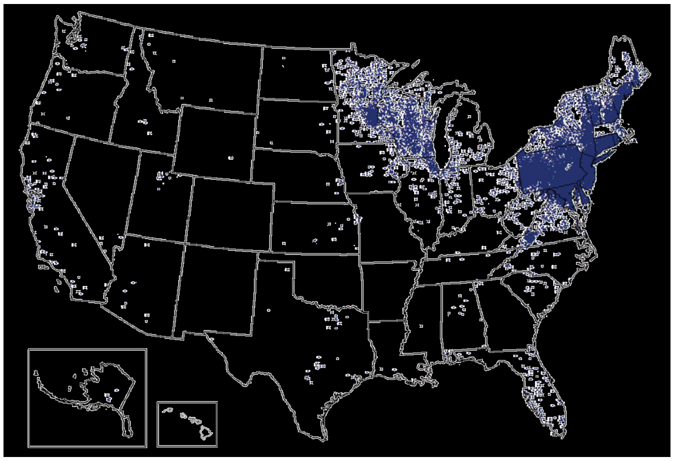

Figure 15: Reported cases of Lyme disease in the U.S. in 2016.
Source: CDC Lyme Resources Brochure[195]

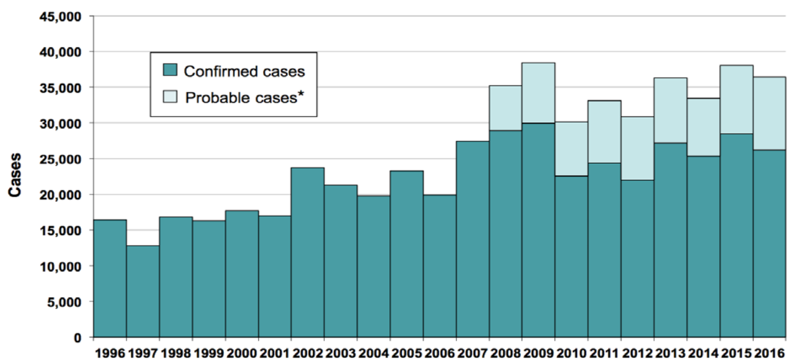

Figure 16: Reported cases of Lyme disease in the U.S., 1996-2016.
Source: CDC Lyme Resources Brochure195

Modelling by Brownstein et al. (2005):[196] "generated the current pattern of *I. scapularis* across North America with an accuracy of 89% ($P < 0.0001$). Extrapolation of the model revealed a significant expansion of *I. scapularis* north into Canada with an increase in suitable habitat of 213% by the 2080s. Climate change will also result in a retraction of the vector from the southern U.S. and movement into the central U.S." As their modelled transmission zone migrates northwards into Canada over the next 70 years, it retreats from Florida and Texas, and the population exposed to Lyme *diminishes*, by 28% in the 2020s, by 12.7% in the 2050s and by 1.9% in the 2080s. The connection between suitable *I.scapularis* and deciduous forest is so strong that the authors state: "Recent emergence of Lyme disease throughout the northeastern and mid-Atlantic states has been linked to reforestation." The motor car may thus have contributed to the emergence of Lyme disease by converting numerous redundant horse-paddocks into woodlands and by fertilizing them with carbon dioxide. The focus should be on educating the public, early diagnosis and treatment rather than on climate mitigation.

Leishmaniasis, from over 20 *Leishmania* species of protozoa parasite, is transmitted by an infected female sandfly, with over 50 species of the genus *Phlebotomus* in the Old World and genus *Lutzomyia* in the New World. The main animal reservoirs include rodents, dogs, wild cats, jackals, foxes, sloths, hyraxes, and other carnivores. It is endemic in 88 countries across Africa, Asia, Europe, and North and South America, infecting up to a million people and killing up to 30,000 annually, mainly among the poorest people on Earth.[197] It is associated with malnutrition, population displacement, poor housing, a weak immune system and lack of financial resources. It is also linked to environmental changes such as deforestation, building of dams, irrigation schemes, and urbanization. Manifesting as visceral, cutaneous, or mucocutaneous forms,[198] the most common is cutaneous leishmaniasis which occurs in the Americas, the Mediterranean basin, central Asia and the Middle East.[199] In North America, leishmaniasis is endemic in Mexico and Texas and has begun to expand its range northward (Fig. 17).

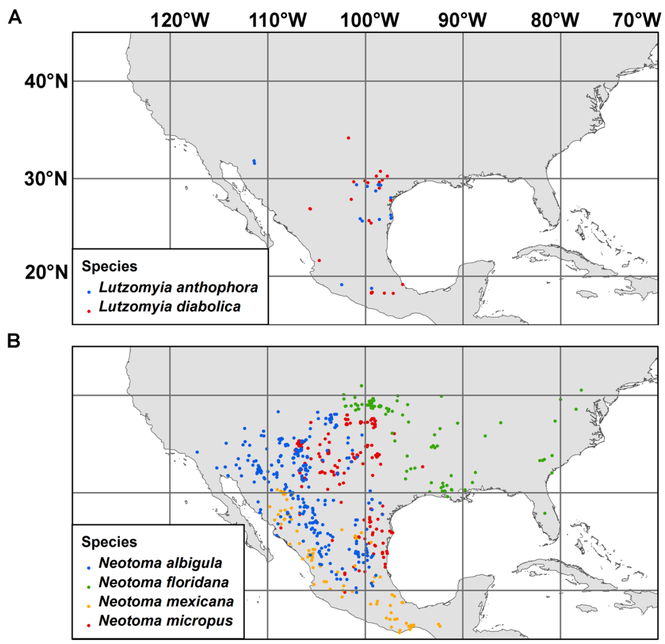

Figure 17: Vector and reservoir data points in North America (2009 data) .A: Both vector species. B: All four reservoir species. Source: [Gonzalez et al. Fig.1 (2010)][200]

Modelling extending the risk of human exposure northwards, even into southern Canada, with climate change,[200] assumes that the United States will be no more effective than African nations in preventing the spread of this disease and its vectors.

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Leptospirosis is a zoonotic disease acquired from infected animals, soil or water, especially flood water contaminated with rat urine. Globally, there are about a million severe cases and 60,000 deaths reported annually. Recent unprecedented outbreaks have been blamed on climate change, but the main reason is population growth plus poverty resulting in urban slums in developing countries.[201]

Extreme Weather Events

It is now widely believed that tropical cyclones, wild storms, tornadoes, floods, droughts, heatwaves and wildfires are increasing in frequency and/or severity due to climate change, thus posing an existential threat to humanity.

Tropical cyclones, termed **hurricanes** in the North Atlantic and **typhoons** in the Northwest Pacific, rank among the deadliest of natural disasters due to wind speed (120-300+ km/h), storm surge and flooding rain. A tropical cyclone killed an estimated 300,000 people in what is now Bangladesh in 1970.[202] The deadliest Atlantic hurricane was probably the Great Hurricane of 1780,[203] which took about 22,000 lives. Major hurricanes hit New York City in 1815[204] and 1821,[205] and another in 1893.[206] Atlantic hurricane activity declined from around 1800 and became unusually quiet from 1970 to 1995 (Fig. 18).

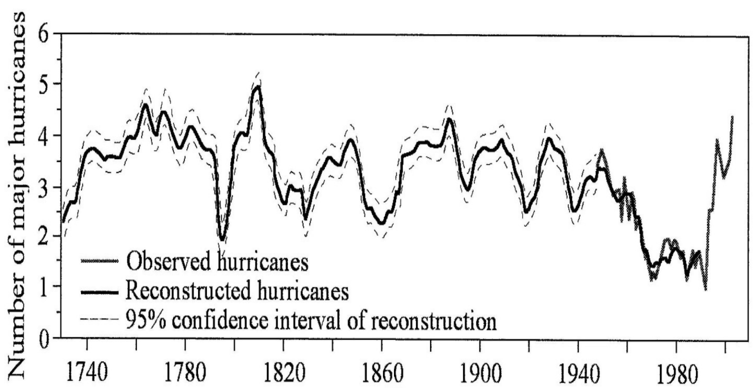

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Figure 18: Annual Number of Major Atlantic Basin Hurricanes, 1730-2005: Reconstructed from coral and plankton sediments in the Caribbean Sea and matched observations.
Source: Nyberg et al. (2005)[207]

Klotzbach et al. (2018)[208] conducted a comprehensive evaluation of landfalling hurricane data for the Continental U.S. from 1900, updated through 2024 in figure. 21. While the largest numbers of landfalling hurricanes occurred in 2004-5, with 4 major hurricane landfalls in 2005, there is no statistically significant trend. No major hurricanes hit the U.S during the 2006-2016 decade, the longest such period since 1920.[209]

Typhoons account for nearly a third of the world's tropical cyclones. [210] The deadliest, Typhoon Nina, took 230,000 lives in 1975, nearly half being caused by 12 Chinese reservoirs failing.[211] The second deadliest, Typhoon Haiyan, had wind speeds up to 315km/h and took 6,352 lives in 2013. [212] The most intense was Typhoon Tip in 1979,[213] with wind speeds over 350km/h before making landfall in the central Philippines. The Joint Typhoon Warning Centre began identifying super typhoons with wind speeds>150mph (240km/h) in 1947, listing ten fewer during the last 2015-24 decade than during the 1952-61 decade.[214]

Water vapor reaching high altitudes and precipitating as cyclonic rain contains a higher proportion of the oxygen-16 isotope than the heavier oxygen-18 isotope. Nott et al (2007)[215] used this to analyze cyclonic activity over 800 years from stalagmites in a Chillagoe cave in North Queensland and confirmed a close correlation with the 20th century historical record. They were surprised to find the most intense cyclones occurred during the Little Ice Age (Fig. 19). From "a new tropical cyclone activity index spanning the last 1,500 years", Haig and Nott (2016)[216] found that "solar forcing largely drives decadal, interdecadal, and centennial cycles within the tropical cyclone record." The frequency and intensity of tropical cyclones in North Queensland continue to decline (Fig. 20).

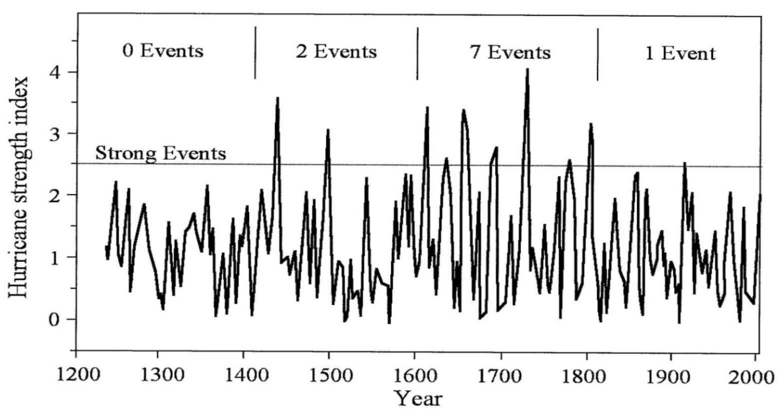

Figure 19: Strength Index of Tropical Cyclone Events in North Qld., 1226-2003
Source: Nott et al 2007.

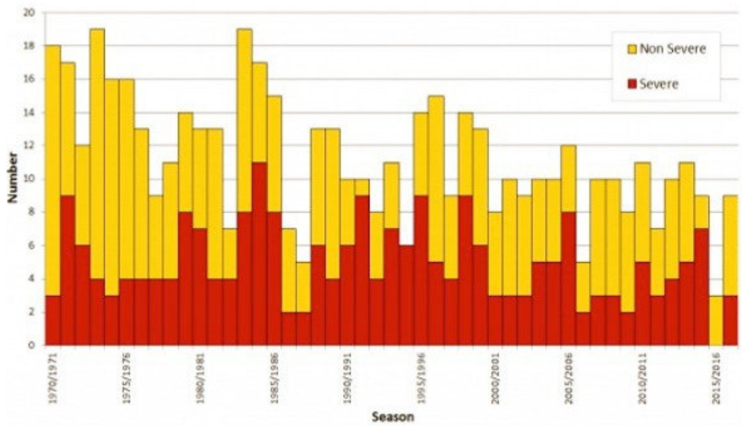

Figure 20: Number of severe and non-severe tropical cyclones in Australia, 1970-2017. Severe tropical cyclones are those with a minimum central pressure less than 970 hPa.
Source: *Bureau of Meteorology*[217]

Cyclones have caused over 2,100 deaths in Australia since 1839,[218] the deadliest being category 5 Cyclone Mahina,[219] killing over 300 people in 1899. Thanks to better forecast and warning systems, and to improved building codes in cyclone-prone regions, the loss of life from cyclonic activity is now rare. Category 5 Cyclone Yasi did not cause a single death in 2011.[220] While deaths declined dramatically, damages increased but not due to climate change. The World Meteorological Organization states: "The recent increase in societal impact from tropical cyclones has largely been caused by rising concentrations of population and infrastructure in coastal regions." [221] After normalizing the mainland U.S. hurricane damage from 1900 to 2005 at 2005-values, Pielke *et al.* (2008)[222] found no trend in damages. The greatest normalized damage ($157 billion) was from the 1926 Miami hurricane.[223]

Hailstorms The deadliest storm killed 1,300 people in the Manikganj District of Bangladesh in April 1989. [224] Hail the size of cricket balls killed 246 people near Moradabad, India, in April 1888.[225] A similar hailstorm hit Sydney[226] on 14 April 1999, inflicting enormous damages but killed no one, the essential difference being wealth and warning systems. An analysis of hail pads in France from 1990 to 2010 by Hermida et al (2013)[227] showed an upward trend in 154 (significant in 10%) and a downward trend in 177 (significant in 17%). Changnon and Changnon (2000)[228] assessed hail-day trends from carefully screened records of 66 stations across the United States over a 100-yr period, 1896-1995, and found five types of 20-year fluctuation:

One present in the Midwest had a peak in hail activity in 1916–35 followed by a general decline to 1976–95. Another distribution had a mid-century peak and was found at stations in three areas: the central high plains, northern Rockies, and East Coast. The third distribution peaked during 1956–75 and was found at stations in the northern and south-central high plains. The fourth temporal distribution showed a steady increase during the 100-yr period, peaking in 1976–95, and was found in an area from the Pacific Northwest to the central Rockies and southern plains. The fifth distribution found at stations in the eastern Gulf Coast had a maximum at the beginning of the century and declined thereafter. The 100-yr linear trends defined four regions across the United States with significant up trends in the high plains, central Rockies, and southeast, but with decreasing trends elsewhere in the nation. . . The national average based on all station hail values formed a bell-shaped 100-yr distribution with hail occurrences peaking in mid-century.

Tornadoes in the U.S. may have increased in number but have decreased in severity since recording began in 1950 (Fig. 21). NOAA explains: "The increase in tornado reports over the last 54 years is almost entirely due to secular trends such as population increase, increased tornado awareness, and more robust and advanced reporting networks."[229] Tornado activity increases with La Niña events, when the eastern Pacific Ocean is cool, and decreases during El Niño events.[230] The **2011 tornado season, for example, was particularly active (1,676 tornadoes), deadly (553 deaths) and costly (>$28 billion)** [231] **while 2016 was unusually quiet (18 deaths).** Over three times as many deaths occurred during the warming-hiatus decade as during the recent rapidly warming decade (1,084 from 2005 to 2014 and 350 from 2015 to 2024).[232]

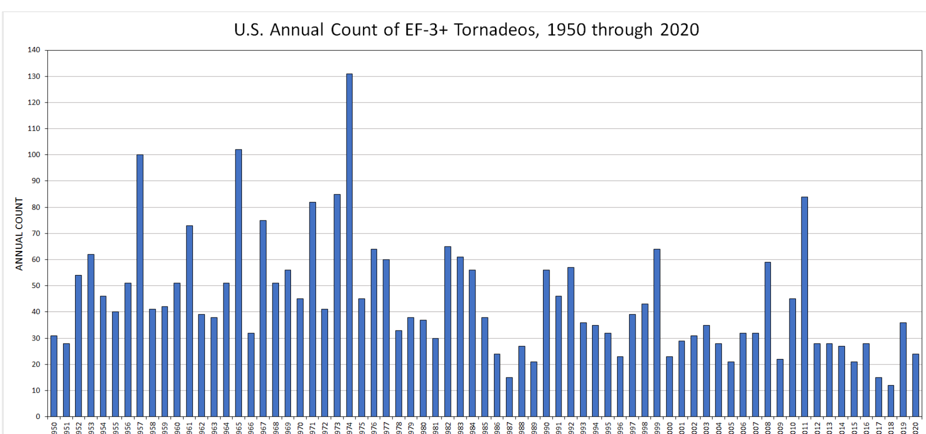

Figure 21: Annual number of strong tornadoes across the United States, 1950-2020.
Source: NCDC/NOAA[233]

Floods take many lives and impact the health of survivors, often long after the event. The world's deadliest flood occurred when China's Huang He (Yellow) River killed seven million people in 1332. The next most deadly occurred when the same river killed between one and four million people in 1887 and 1931.[234] Approximately 100,000 flood fatalities occurred in England and the Netherlands in 1099, another 80,000 in the Netherlands when the Great Storm broke a dike in 1287, and another 10,000 from a similar incident in 1421. Late-thaw ice jams blocked swollen rivers and burst dikes in the Netherlands during the cold 18th century.[235] The highest flood risk in Germany's River Werra was in the 1700's.[236] California's worst recorded flood occurred during 1861-1862 when nearly 10 feet of rain submerged the entire Central Valley for weeks.[237] Flooding of the river Vltava in the Czech Republic decreased over the last century.[238] Australia's Mary River had its worst recorded flood in 1893, with Aboriginal legends of even worse floods.[239]. Brisbane had more frequent and severe recorded floods during the 19th century than the subsequent 125 years, the highest being in 1841 and the next highest in 1893 (Fig. 22). A global analysis of nearly 200 rivers revealed that flows over the last century were unchanged in the majority, increasing in 27 and decreasing in 31.[240] This is also true for those rivers with observations stretching back much further in time.[241] The IPCC's AR5[242] agrees: "There continues to be a lack of evidence and thus low confidence regarding the sign of trend in the magnitude and/or frequency of floods on a global scale." Christy et al (2025) computed the 26 highest 5-day precipitation totals every 5 years over 130 years at 29 recoding stations on the Pacific coast and found no trends (Fig 23) Deluges associated with the massive 1997-98 El Niño event is apparent. They likewise found no trends in the humid Southeast nor the Northeast of the U.S.[226]

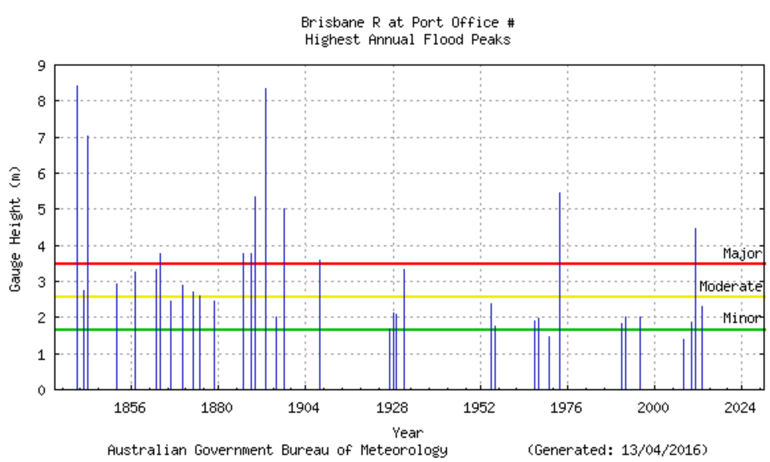

Figure 22: Brisbane River heights in metres, 1840-2016.
Source: Australian Bureau of Meteorology[243]

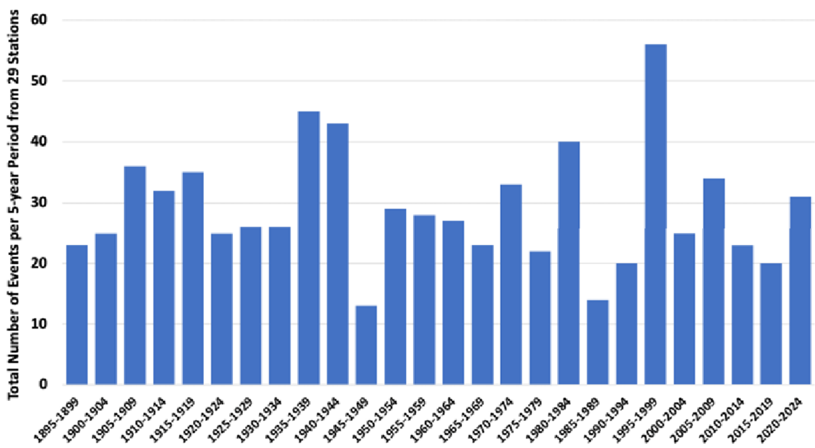

Figure 23: Time distribution by 5-year periods of the 26 heaviest (1-in-5 yr) occurrences for 29 stations on the Pacific coast. Source: Christy et al 2025 (Figure 6.4.2)

Most flood fatalities occurring worldwide between 2005 and 2014 were in Asia and among women.[244] Haynes et al. (2016)[245] analyzed 1,859 Australian flood fatalities from 1900 to 2015 and found a dramatic decline (Fig. 24). Ashley and Ashley (2008)[246] found no statistically significant trend in fatalities over the period 1959-2005 in the United States (Fig. 25).

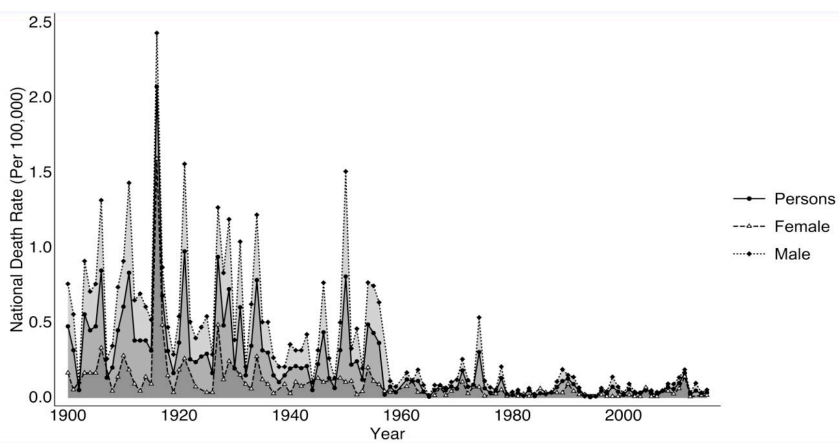

Figure 24: Australian flood fatality rate from 1900 to 2015. Source: Haynes et al. (2016)[245]

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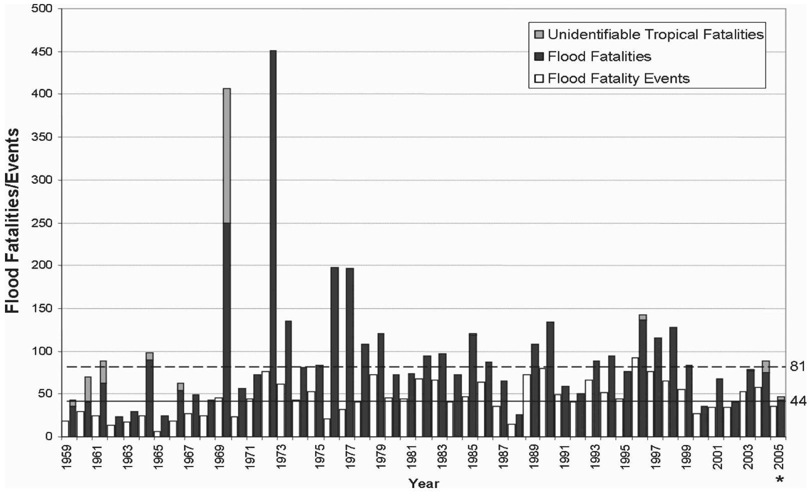

Figure 25: Flood fatalities in the continental United States, 1959-2005. Black bars represent deaths due strictly to flooding for all event types in the study. Gray bars represent deaths due to tropical systems but not to flooding alone. Light grey bars represent deadly events. The dashed horizontal line represents yearly fatality median, and the non-dashed horizontal line represents yearly fatality event median. The asterisk indicates that 2005 data are preliminary and do not include Hurricane Katrina fatalities from Louisiana.

(Source: Ashley and Ashley 2008)

The Australian evidence indicates that the solution to flooding is not climate mitigation but better infrastructure, warning systems, evacuation centers, rescue services etc. While flood casualties have been declining, health problems associated with dislocation and economic losses have been increasing due to population growth, especially along waterways. Altered land use and loss of flood plains and wetlands impacts flooding far more than does climate change. Bjorn Lomborg put it simply and starkly: "A dollar spent on flood management will reduce flooding 1,300 times better than a dollar spent on Kyoto."[247]

Drought in the American west is often attributed to climate change, but accurate records of precipitation going back to 1895 indicate no significant trend in either the Southwest or Northwest Regions.[248] After demonstrating a robust relationship between tree-rings and observed Colorado River flows over the 20th century, Meko et al (2007)[249] examined these proxies back to 762CE and found many more severe droughts, the worst occupying almost the entire 12th century (Fig. 26).

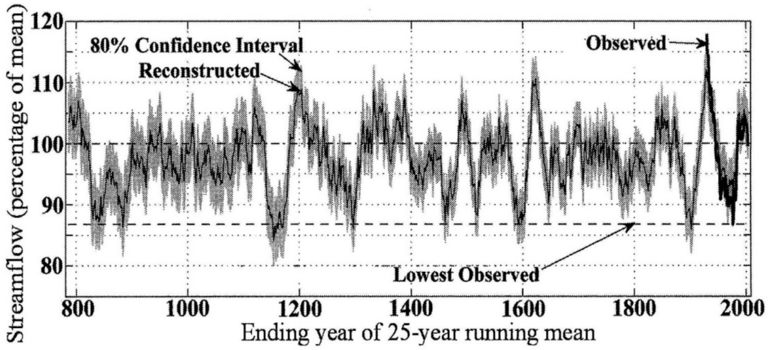

Figure 26: Colorado River stream flow, Observed: 1905-2005 & Reconstructed from Tree Rings: 762-2005
Source: Adapted from Meko et al, 2007.

Models project wet regions becoming wetter and dry regions drier,[250] but Sun et al. (2012)[251] found that wet areas got drier and dry areas got wetter from 1940 to 2005, and Greve et al. (2014) [252] found no difference.

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Leaf stomata density and water loss decrease as atmospheric CO_2 increases;[253] thus increasing drought tolerance. From 1982 to 2012, **CO_2 increased by 15% and** vegetation cover increased by 11% in *arid* areas.[254] Scientists once worried about increasing desertification due to climate change[255] but now worry about a greening planet[256] and shrinking deserts![257]

Commented [AW5]: Why is this bold?

Konzmann et al. (2013)[258] estimated that global irrigation demand will decline by about 17% by the 2080s due to a combination of increasing carbon dioxide, shorter growing periods and precipitation increases. Wiltshire et al. (2013)[259] estimate that population growth will increase the number at risk of water stress from 2.6 billion to 4.1 billion in 2000 but to only 2.9 billion under the IPCC's A1FI scenario with the benefits of CO_2 factored in; the higher the CO_2, the greater the risk reduction.

Wildfires can cause not only immediate death and destruction but also protracted mental health consequences for firefighters[260] and survivors, especially those losing loved ones, livelihoods and/or property, over many months or even years.[261] Toxic and potentially carcinogenic smoke can also impact health, even hundreds of kilometers away.[262] Particulate matter smaller than 2.5 microns ($PM_{2.5}$) from wildfires is more toxic to the respiratory system than equivalent concentrations of $PM_{2.5}$ from background urban sources.[263] Johnson et al (2012) [264] estimated that the smoke from wildfires kills over 300,000 people globally, mostly in Africa and Asia and especially among the elderly and those with chronic heart and lung conditions. [265] [266] The annual PM2.5 emissions from wildfires have significantly declined this century except in Canada.[267] Wildfires in catchment areas can also reduce runoff by as much as 50%, as trees regenerate over subsequent years or decades,[268] and render it temporarily unfit for human consumption.[269]

The burning question, of course, is whether wildfires are caused by climate change. The burned area in the U.S. and globally declined last century,[270] by 27% this century and on every continent,[267] but the intensity of wildfires may be increasing in some areas.[271] Increased forest fire frequency, intensity and/or duration of fire season has been observed in Africa,[272] South Africa,[273] Australia,[274] Alaska,[275] Canada,[276] western USA,[277] Russia[278] and Spain,[279] but this does not necessarily incriminate climate change. Whereas the 2019-20 Australian summer bushfires, attributed to climate change, [280] burnt 7% of New South Wales, a quarter of Victoria burnt back in 1851,[281] after white settlement had disrupted thousands of years of traditional cool burning of a fire-prone region with wet winters and hot dry summers. The highest profile forest fire in the U.S. West, the 1910 Big Blowup fire which destroyed over three million acres and entire towns, led the U.S. Forest Service to focus on fire suppression of all forest fires until the U.S. Forest Service recognised that more frequent smaller prescribed burns, fuel elimination, and controlled wildfires are more appropriate[282] and result in healthier forests, water ecosystems and biodiversity.[283]

Wildfires require a fuel load (dry, flammable vegetation), suitable weather (hot dry winds), and an ignition source (natural or human). Increasing carbon dioxide can increase all three: fuel loads via CO_2-fertilisation, warmer and wetter growth conditions,[284] combustibility via increased temperatures,[285] and ignition via lightning strikes.[286] It is not that simple, however. Increased atmospheric CO_2 benefits (C3) trees more than (C4) grasses, which dry out and burn faster, and survive fires. Deforestation in the tropics is a major fire factor.[268] Ecosystem models tend to overestimate precipitation and the growth response to it. They don't include plant diversity, evapotranspiration and ground water, mineral composition of the soil, forest management, grazing, changes in cultivation practices and varieties, irrigation, storms, insect attacks and other disturbances which together contribute more to fuel load variations.[287] Greenhouse gases impact winter minimums much more than summer maximum temperatures. Lightning strikes, thought to increase by 5-6% per degree (1^{o}C) of warming, account for very few ignitions.[288] Balch et al. (2017)[289] evaluated over 1.5 million government records of wildfires in the U.S. from 1992 to 2012 and found that humans accounted for 84% of them and that the human-caused fire season was three times longer than the lightening-caused fire season. Whereas human ignition accounted for 5.1 million km^2, lightning accounted for only 0.7 million km^2, primarily in sparsely populated mountainous areas of the western United States. Many wildfires, such as California's Wine Country fires in 2017, are started by downed power lines in high winds.[290]

The human impact on wildfires also involves controlled burning, firebreaks, clearing around dwellings, fire protection, warning systems, fire-fighting capabilities and demographics. Most buildings affected by major bushfires in Australia are within 100 meters of bushland, and many back right onto it.[291] Altered ecosystems can also have a profound impact; the introduction of African gamba grass[292] to northern Australia has greatly intensified wildfires there. Curran, Perry and Wyse (2017)[293] point out that: "Plantations of highly flammable exotic species, such as pines and eucalypts, probably helped to fuel the recent catastrophic fires in Portugal and in Chile. In arid regions, such as parts of the U.S. southwest, the introduction of exotic grasses has transformed shrublands, as fires increase in severity." Focusing on CO_2 to prevent wildfires may be as misguided as the former focus on eggs to prevent heart attacks and diverts attention from proven preventive measures:

- Adequate and properly maintained firebreaks, including green firebreaks
- Preventing or limiting the spread of highly flammable exotics
- Maintaining safe electrical networks, placing them underground in high-risk areas
- Regular planned/controlled burning at appropriate times/weather conditions
- Timely effective communication to the public of fire risk, planned burns and smoke pollution
- Making dwellings as fire-resistant and smoke-proof (sealed) as possible
- Using effective air cleaners to reduce indoor smoke pollution, especially for asthmatics.

Denying the use of fossil fuels for such preventive measures and for firefighting could cost countless lives.

Food, Famine, Climate and CO_2

In his 1968 book *The Population Bomb*, Paul Ehrlich predicted widespread famine with hundreds of millions starving to death in the 1970s, but the death toll declined as the population grew (Fig. 27).

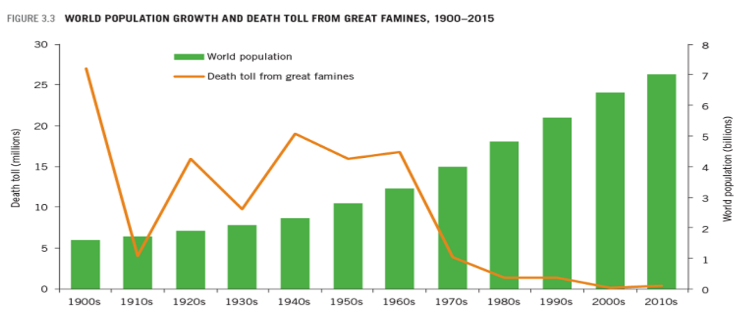

Figure 27: Global population (billions) and mortality from great famines (millions)

While pessimists panicked, Norman Borlaug, a Minnesota agronomist, quietly launched a green revolution in Mexico, which became a net wheat exporter in 1963, in the Philippines, which became a rice exporter in 1968, and India and Pakistan which had more than doubled their wheat production when "the man who saved a billion lives" was awarded the Nobel Peace Prize in 1970. Thanks to his disease-resistant high-yield hybrids and fertilizers, global food production increased from 1961 to 2005 by 2.3% pa (35% faster than the population rate of 1.7% pa). Food consumption increased from 2280 kcal/d to 2800 kcal/d per person as agricultural production grew along with GDP.[294] In *Nature Climate Change*, Asseng et al (2015) [295] warned: "Warming is already slowing yield gains at a majority of wheat-growing locations. Global wheat production is estimated to fall by 6% for each °C of further temperature increase." Despite subsequent warming, *The Times of India* (17 August 2017)[296] reported a record food-grain production, up 4% on the previous record, a five-fold increase since 1951 and a four-fold yield per hectare. The global wheat production also reached record levels due to increases in India, Russia and the U.S. (Fig. 28). New d**urum varieties can withstand 40°C temperatures.** [297]

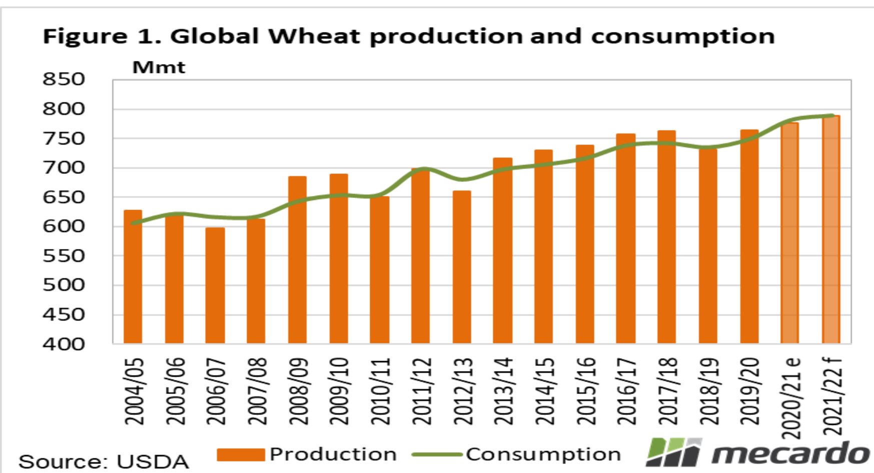

Figure 28: Global wheat production and consumption 2004-2022

Global warming has **extended the arable area, growth rate and growing season for food crops.**[298] **From 1980 to 2003, global food production increased by 62.8% as atmospheric CO_2 increased by 11.2%, fertilizer use by 27.5% and land use barely at all.**[299] **Numerous studies of CO_2 enrichment have demonstrated dramatically improved crop yields.**[300, 301] **It also reduces water requirements and** mitigates drought.[302] Horticulturalists increase it two and a half times the present atmospheric level in greenhouses. **Ainsworth-Long (2005)**[303] **performed a meta-analysis of 124 papers on 40 species tested at 12 sites, 7 in the USA, 3 in Europe, 2 in New Zealand and Japan, using free-air CO_2 enrichment (FACE) to around 550 ppm. The actual**

increases achieved (above the ambient CO_2 level at the time of the study) varied from 30.5% to 68% with an average of 49.2%. They found that trees benefited the most, more than anticipated from chamber studies, while crop yields increased by 17% on average, less than expected from chamber studies. Sorghum yields increased by as much as 28% under dry conditions, due to reduced water loss from fewer transpiration stomata. Light-saturated CO_2 uptake was increased by 19% at temperatures under 25°C and by 30% at higher temperatures, indicating better heat-tolerance under elevated CO_2.[304] Two FACE facilities using CO_2 at up to 200 ppm above ambient levels produced a 5-7% increase in rice yield and 8% increase in wheat yield, which would result in an extra 59 million metric tons a year globally, enough to feed an extra 550 million mouths at the average per capita consumption. Reducing it to preindustrial levels would put billions of lives at risk of starvation and constitute a crime against humanity.

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The U.S. National Bureau of Economic Research matched satellite-based observations of outdoor CO_2 levels across the U.S. with county-level agricultural output data and other economic variables and concluded that CO_2 emissions had boosted U.S. crop production since 1940 by 50 to 80%, much larger than previous estimations using FACE experiments, and found that every ppm of increase in CO_2 boosts corn yields by 0.5%, soybeans by 0.6%, and wheat by 0.8 % (Fig. 29).[305]

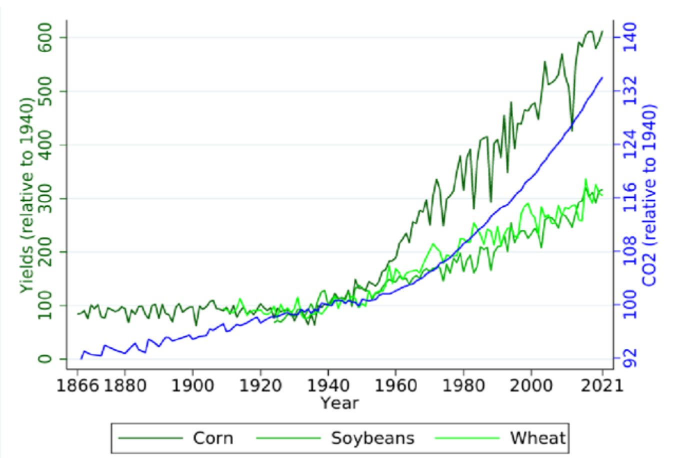

Figure 29: U.S. average CO_2 levels and yields of corn, soy and wheat all normalized so 1940=100. Source: Taylor and Schlenker (2023)

Climate activists focus on the fact that CO_2 enrichment lowers the protein and mineral content of some foods, but genotype selection and nitrogen/mineral fertilization can maintain protein/mineral content.[306,307] CO_2 enhancement significantly increases the flavonoid/antioxidant content of wheat[308] and strawberries:[309] by 55% and 112%, ascorbic acid (vitamin C) by 10% and 13% and glutathione by 3% and 171% at 300 ppm and 600 ppm respectively. Tomatoes grown in enriched CO_2 are higher in vitamins A [310] and C.[311] Idso et al. (2002)[312] found that CO_2-enriched oranges were 4% heavier, 74% more in number and 5% higher in vitamin C. Soy beans grown from seedlings in CO_2 at 700 ppm (compared to 400 ppm) had an isoflavone content 8% higher when grown at the usual mean temperature of 18^{o}C, 104% higher when grown at 23^{o}C and 101% higher at 28^{o}C.[313] When drought was added to heat stress, the isoflavone content was 38-186% higher in plants exposed to 700 ppm. Kim et al (2005) likewise found a 72% increase in soy isoflavones grown at 650ppm (vs. 360 ppm), and a 96% increase in total plant biomass. Broccoli grown in 65%-enriched CO_2 produced heads 7% heavier and containing 37% more glucosinolates.[314] These not only enhance flavor but also help to prevent cancer.[315] Similar results were found with Chinese kale.[316] Growing spinach at 800 ppm increased the fresh weight by 67%, the soluble protein concentration by about 52% and vitamin C by 21%.[317] Gwynn-Jones et al. (2012)[318] found that quercetin glycosides and various other antioxidants were significantly higher in several types of berry consumed by humans and other animals at Northern Latitudes when grown at 600 ppm. It is very likely that CO_2 has been quietly improving food quantity and quality.

Global food security depends not only on production but also on distribution and transport, which invariably involves the use of fossil fuels. Misguided climate action can threaten food security. The diversion of good food into biofuel may **have pushed 130-155 million people into absolute poverty, hunger and starvation in 2008 and caused 190,000 premature deaths in 2010.** [319] **In 2007,** Australia's CSIRO warned: "If all of the ethanol capacity that is currently proposed was to be fulfilled by existing crops (principally wheat and sugar), or if a national E10 target were to be met (eg. by 5.5 Mt of wheat as the feedstock), it could force the import of wheat in drought years." Despite a severe U.S. drought in 2012, 40% of its corn crop[320] went into ethanol. Researchers noted the real irony as follows: "Once estimates from the literature for process emissions and displacement effects including land-use change are considered, the conclusion is that U.S. biofuel use to date is associated with a net increase rather than a net decrease in CO_2 emissions."[321] What folly!

Seafood supplies about 10% of the world's human calorific intake[322] and is an important source of omega-3 fatty acids (ω-3 FAs) which may reduce cardiovascular morbidity and mortality and benefit some metabolic, inflammatory, neurological, neuropsychiatric and eye disorders.[323] It is thought that increasing CO_2 will impact seafood via higher sea surface temperatures, ocean 'acidification' (reduced alkalinity), altered precipitation and sea level rise. Cheung et al. (2009)[324] rely on unlikely emissions scenarios and temperature projections to "show that climate change may lead to large-scale redistribution of global catch potential, with an average of 30–70% increase in high-latitude regions and a drop of up to 40% in the tropics." Crustaceans (crabs, lobsters, shrimps and krill) appear to benefit from more dissolved CO_2 even at many times today's atmospheric level.[325] Samaila, Cheung et al (2011) put climate change into perspective: "Global marine fisheries are underperforming economically because of overfishing, pollution and habitat degradation."[326] Protecting and promoting sea grass will increase seafood supplies and mitigate climate change more effectively than focusing on emissions.[327]

Mental Health

We are now seeing a global epidemic of climate-related eco-anxiety (fear, guilt, hopelessness, depression, anger, grief, shame, hopelessness etc.) among children and young people, affecting 84% of the latter and negatively affecting the daily life and function of nearly half.[328] [329] Many are so convinced that climate change is an existential threat that they elect not to propagate the race! [ibid] A study of 5,500 Australian adults found that 25% met the screening criteria for clinical anxiety or trauma related to climate change, and 20% of those aged 18-34 were functionally impaired by it.[330] Why are the children and young people so anxious about climate change? One reason is that the media now links climate change to almost every extreme weather and wildfire event, labelling many of them 'unprecedented'. Older people with long memories have a better perspective.

A more sinister reason is the deliberate indoctrination of the young. A 2007 survey of 600 Australian children aged 10-14 who had recently been shown Al Gore's docudrama, *An Inconvenient Truth***,**[331] emotively depicting drowning polar bears, oceans rising 20 feet, dreadful epidemics and more happening very soon unless we **'save the planet', found** that 44% were nervous about the future impact of climate change and 25% believed the world would end before they got much older.[332] Another survey of 200 schoolchildren in New South Wales likewise found that fears over climate change were producing feelings of powerlessness and despair: "Many children thought they would not survive to adulthood."[333] Teachers are now encouraged to use 'sustainable' educational material,[334] some of it apocalyptic predictions and frightening propaganda bordering on child abuse.

Dire predictions are often based on flawed models, exaggerations, wild imaginations and a failure to factor in human ingenuity.[335] Predictions made in the 1970s of an impending ice age, falling crop yields, increasing global famine, advancing deserts, a pesticide-induced cancer epidemic, of oil, gas and other resources rapidly running out, were not only wrong but the very opposite has happened. More recent predictions of malaria spreading across the globe, Arctic ice disappearing by 2013, increasing droughts and tropical cyclones have all failed to materialize. Indeed, the world has never been safer than now (Fig. 30).

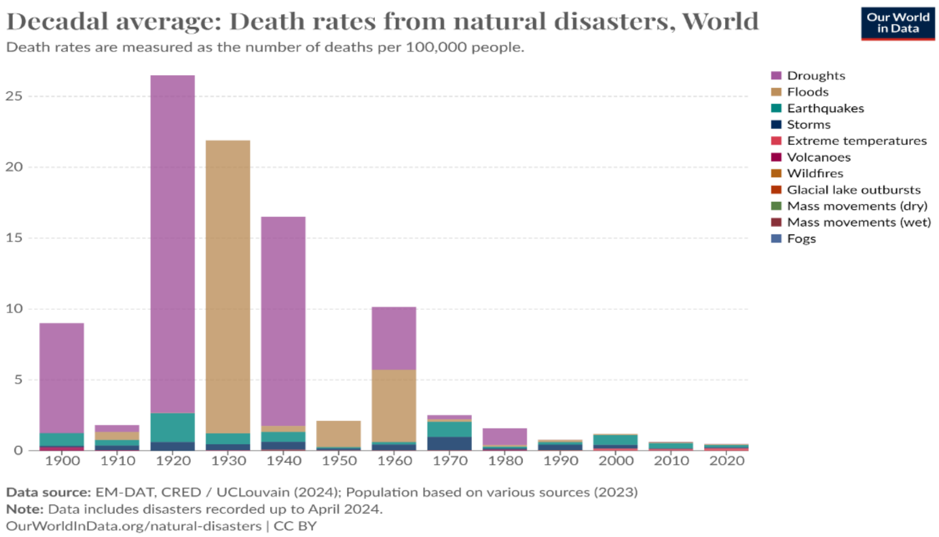

Figure 30: Global mortality from natural disasters from 1900 to 2024

Child psychologist Clare Rowe has seen many cases of eco-anxiety including an 8-year-old girl with "a deep and persistent fear about her family's car usage. She would cry and refuse to get in the vehicle, believing that each trip was directly killing the planet."[336] Childhood anxiety is normally treated by offering realistic perspectives and reassuring safety but "when it comes to climate change, we abandon this approach entirely and instead of reassurance, we validate their fears. We even encourage them to remain anxious as a form of moral engagement." [ibid] Australian doctors are also advised "to avoid invalidating when challenging thoughts and feelings about climate change" and to "not dispute the accuracy or otherwise of thoughts" but rather "identify action which is meaningful and sustainable for them (e.g., eating less meat or joining a local environmental group)."**[337]** When this was challenged, and their assertion that climate change is a "significant existential threat that most Australians are rationally worried about", the authors dismissed dozens of cited scientific papers as "outlier opinion and research" in favor of an authoritative "consensus of the global scientific community".[338]

The academic left first quarreled with science[339] before capturing, corrupting and politicizing it.[340] [341] [342] They then ignored quantitative uncertainties[343] to contrive a catastrophic climate change consensus,[344] calling sceptics *deniers* [345] and inventing a climate crisis and global boiling[346] to foster fear, funding and a rush to renewables. Anthropocentric purists prohibit alternative diagnoses, prognoses, priorities or remedies and suspect fossil fuel funding behind anyone challenging "The Science". Climate change does impact the poorest the most but, as we shall see in the next section, a lucrative climate industry makes them even poorer and more vulnerable.

Energy Sources and Health

Humanity has climbed an energy ladder from burning biomass (wood, charcoal, crop waste and dung) to wind and hydropower (windmills and watermills) to fossil fuels (coal, oil and gas) and biofuels (ethanol and biodiesel), to nuclear power, solar (photovoltaic and thermal) and then back to wind power (turbines).

Biomass accounts for about 10% of global energy consumption[347] and around 90% in South Asia and sub-Saharan Africa (except South Africa).[348] It is unquestionably the most air-polluting and lethal of all energy sources. According to the WHO,[349] over 2 billion people (around a third of the world's population) still cook and heat their homes using biomass, estimated in 2020 to cause 3.2 million deaths a year: 32% from heart disease, 23% from stroke, 21% from pneumonia, 19% from chronic obstructive pulmonary disease (COPD), and 6% from lung cancer. Lelieveld et al. (2015)[350] attributed 90% of the ambient air pollution in South Asian megacities to the burning of biomass in homes. This led Mikko Paunio,[351] an epidemiologist at the University of Helsinki, to state: "Perhaps around six million deaths globally are attributable to domestic combustion of solid (bio)fuels. However, despite these appalling statistics, the development community has focused its efforts on mitigating global warming instead. Some ... have even encouraged the burning of crop residues in homes. The effect of this headlong rush to 'save the climate' has horrifying implications for human health." Paunio also points out that burning wood pellets in Europe is not only more polluting than coal but also destroying forests and increasing CO_2 emissions.[352]

A large prospective study from 2000 to 2009 across the United States indicated that fine particulate matter (≤2.5 microns or PM2.5) levels over 10μg/m^3 increased total mortality by 3%, CVD mortality by 10% and respiratory mortality in never smokers by 27%.[353] The most air-polluted region of the planet, with an annual mean ambient PM 2.5 of greater than 26μg/m^3, stretches band-like from northwest Africa across Arabia and northern India to eastern China; countries with the highest CO_2 emissions per capita, Australia, Canada and United States, have among the lowest actual air pollution (i.e. PM2.5 ≤10μg/m^3); only Siberia, Scandinavia, Scotland and Ireland have less, and the only areas in Australia with a PM2.5 greater than 10μg/m^3 are in the wildfire-affected north and the dry undeveloped centre.[354] The answer to life-threatening air pollution is development, and that requires the intelligent use of fossil fuels.

Coal fueled the Industrial Revolution, allowing machines to replace muscles, thus liberating animals, serfs and slaves and permitting train travel and the rise of a prosperous middle class.

Downsides included hazards associated with the mining, transport and burning of coal. Wikipedia lists 50 mining disasters[355] since 1885, mostly underground cave-ins and explosions. The worst year on record was 1907 when over 3,000 U.S. miners died.[356] Those risks are now greatly reduced by open-cut mining and by automation.[357]

Coal worker pneumoconiosis (CWP), commonly known as 'black lung', took about 25,000 lives globally in 2013,[358] but was almost eliminated in Queensland in the 1970s and in New South Wales a little later (Fig. 31). The U.S. has been less successful in preventing CWP, probably due to the higher quartz content in mine dust.[359] Spraying a bio-degradable binding polymer onto the surface has been shown to reduce coal dust lost to the environment by 75% and this is included in good management controls. [360]

By replacing biomass for cooking and heating and supplying over a third of the world's electricity, coal prevents millions of deaths every year, and many more by helping to lift people out of poverty. High-efficiency low-emission (HELE) power plants[361] use scrubbers and precipitators to remove 99% of the fly ash, 97% of the sulfur dioxide and up to 90% of the nitrogen oxides. New ultra-clean coal (UCC) technologies can remove 99.75% of particulates and almost all the sulfur. Coal power in the U.S. is 17 times safer than in India and China (Table 1). India has huge coal reserves but mostly of low-quality with high ash content.[362]

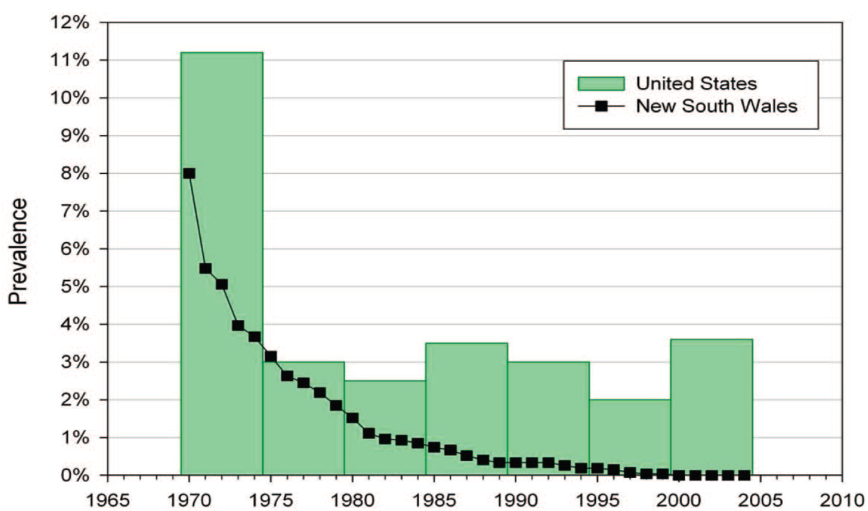

Figure 31: Prevalence of pneumoconiosis among U.S. underground coal miners and NSW coal workers. Source: Joy, Colinet and Landen: CDC[363]

Oil and its distillates (petroleum, kerosene and diesel) revolutionized 20th century transport even more than did coal in the 19th century. It solved the horse dung problem and allowed cities and trees to grow on former denuded horse paddocks. Downsides included the lead added to petrol as anti-knock and other particulates contaminating the air in big cities and the soil along busy roadways until unleaded petrol and catalytic converters were mandated in developed countries in the 1980s.[364] When the EU promoted diesel in 2001 to reduce CO_2 emissions, [365] by 2016 most European cars were diesel, spewing out nitrogen oxides and particulates (soot). In 2007, the U.S. mandated diesel particulate filters which tend to clog up during short trips around town and require periodic long CO_2-emitting trips to remove the accumulated carbon. Even "Euro 6 Standard" vehicles miss their pollution targets by a whopping 400%.[366] A misguided attempt to reduce a non-pollutant actually increased real pollution! After successive Indian governments subsidized diesel to assist farmers, the number of diesel cars increased ten-fold and New Delhi became the city with world's most polluted air, killing up to 50,000 people a year.[367] Biodiesel is no less polluting. EVs recharged overnight with coal-generated electricity may reduce air pollution in cities but are really coal cars. "Just Stop Oil" campaigners depend on oil for food, clothing, accessories, medicine, prosthetics, furniture, phones, electricity (insulation), transport and even the paint they throw on precious artwork!

Gas (methane) produces almost no pollutants and less CO_2 per unit energy than coal, which it is fast replacing in the United States. Fracking for shale gas has a good safety record.[368] [369] Being far more flammable than other fossil fuels, its storage and distribution requires stringent safety standards. Fatal explosions are not uncommon, [370] but, as shown in Table 1, there are far fewer deaths per unit of energy produced than with coal or oil. As the primary source of fertilizer, natural gas saves numerous lives.

Solar power includes photovoltaic (PV) and thermal solar plants, which can store heat for use after dark. There are hazards associated with PV in its manufacturing, rooftop installation, cleaning, servicing and removal/replacement.[371] Potentially toxic materials used in PV manufacture include silicon, gallium arsenide and cadmium.[372] The PV solar industry has become a leading emitter[373] of hexafluoroethane, nitrogen trifluoride and sulfur hexafluoride, all potent and potentially toxic greenhouse gases.[374] Falls from ladders and rooves are the leading cause of fatalities in the U.S. construction industry. Brian Wang (2008)[375] estimated 100-150 fatal falls from solar panel roof installations annually. Per unit of energy produced, the lifecycle CO_2 emissions are four times greater for PV solar than for nuclear power and the quantity of toxic waste (lead, chromium, cadmium etc) is 300 times greater than the nuclear waste, posing a future solar-waste crisis.[376]

Wind power impacts human health in the manufacture and installation of turbines, in the visual amenity, noise, economic and agricultural impacts, many farms now growing turbines instead of turnips! Injuries and fatalities, over 1,500 times U.S. nuclear fatalities per unit of energy produced (Table 1), occur during the transportation, installation and maintenance of turbines.

Sunlight flickering through massive rotating blades can be annoying and even trigger epileptic seizures in susceptible subjects.[377] Studies and reports on wind turbine noise are many, varied and often biased.[378] A comprehensive review by Schmidt and Klokker (2014)[379] found evidence of a dose-response relationship between wind turbine noise and annoyance, sleep disturbance and possibly psychological distress but no statistically-significant association with tinnitus, hearing loss, vertigo or headache. Infrasound in the 5–8 Hz range can cause a rattling of doors and windows which can be annoying to those living close to wind turbines.[380] Tang et al. (2017)[381] found that wind turbines in northern China affected the soil temperature and moisture of nearby farms, thereby reducing gross summer production by 8.9% and annual net production by 4%. Mining and refining rare earths for turbines and EVs pollutes Inner Mongolian lakes with large quantities of toxic and radioactive waste.[382 383]

The major problem with wind and solar is weather-dependent intermittency and unreliability necessitating very costly storage and infrastructure which increase the retail price of dispatchable electricity (Fig. 32) and hence fuel poverty and temperature-related mortality.

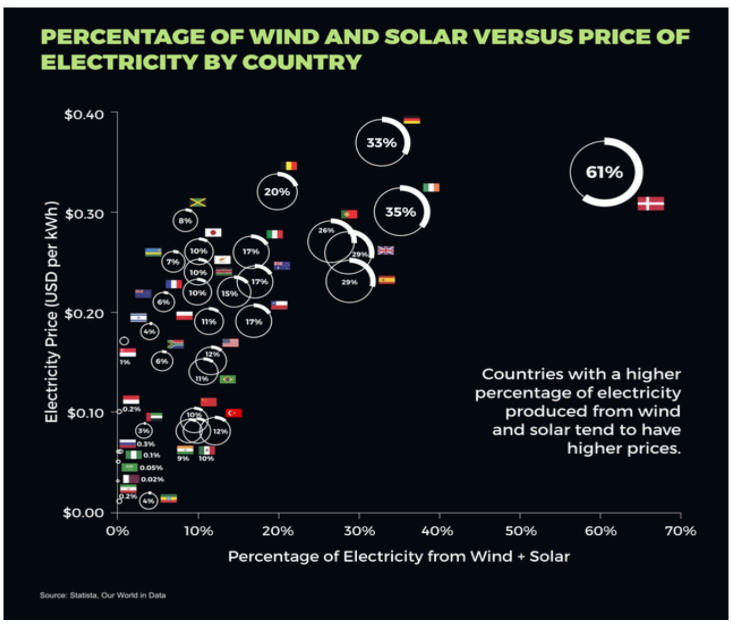

Figure 32: Relationship between electricity prices and percentage of intermittent energy by country in 2021.

Hydropower is the most reliable renewable energy provided the rain comes. Pumped hydro allows surplus wind and solar energy to be stored but is expensive. It is vital that dams and reservoirs are well designed and built only on suitable sites. When the Banqiao dam on the Ru

River in China burst in 1975, more than 170,000 people perished. A 1972 dam failure in Buffalo Creek, West Virginia took 125 lives, injured over 1,100 and left nearly 5,000 people homeless. In 1972, a dam near Rapid City, South Dakota, failed, which flooded the entire downtown during the night. This event killed 237 and injured 2,932 people.[180]

Nuclear power became unpopular after a tsunami hit Fukushima on 11 March 2011, even though no one died from radiation.[384], [385] Nuclear has by far the lowest fatality footprint (Table 1). Even Chernobyl was responsible for fewer than 50 confirmed deaths.[386] Laser enrichment[387] of radioactive waste and fusion breeding[388] might soon revolutionize the nuclear industry, making it more efficient and safer than ever. For optimal health, every country should be free to choose the most affordable and reliable energy sources. Those using coal should be encouraged and perhaps assisted to make it as clean as possible. Most will probably transition to gas and eventually to nuclear energy. Biomass should be phased out, as should all subsidies, and intermittent renewables must remain minor players. The underlying principle should be the conservation and best use of resources.

Table 1: Comparison of energy sources in relation to greenhouse gas (GHG) emissions, energy return on energy invested (EROI), required land and resources, and human mortality rate per unit of energy produced

Metric/Source	Coal (No CCS)	Biomass[1]	Gas (No CCS)	Nuclear	Hydro (Med-Large)	Wind[2]	Solar Silicon PV[3]
GHG Emissions (g CO_2e/kWh)[4]	903	900	449	12	24	12	48
EROEI (buffered)	30.00	3.50	28.00	75.00	35.00	3.90	1.60
Land Use (CCUS) (m^2/MWh)	21.0	760.0	1.3	0.3	14.0	99.0	19.0
Critical Mineral Usage (kg/TWh)	7	7	8	12	6	165	124
Bulk Material Usage (CCUS) (t/TWh)	606	606	713	1,192	15,658	5,931	2,441
Mortality (Deaths/TWh)	64.4	14.3	3.4	0.04	0.71	0.10	0.23
Dispatchable/Intermittent (R/I)	D	D	D	D	D	I	I

1. Biomass gross CO2 emissions per Drax annual report; EROEI for corn biomass; Land Use from Freeing Energy; Mineral usage assumed same as coal
2. Wind land usage taken as median of Our World in Data analysis
3. Solar PV land use assumed ground-based silicon
4. GHG Emissions (except biomass) taken as median from UNECE report p83 https://unece.org/sites/default/files/2021-10/LCA-2.pdf

Conclusion

Warmth is good for human health and prosperity. Fossil fuels have played a vital role in providing the wealth essential for health and environmental protection. They have also boosted atmospheric CO_2 and added a little warmth, both being hitherto beneficial overall for plants and people. The ingenuity of Homo sapiens at adapting to climate has permitted people to populate almost the entire globe from the freezing Arctic to the steamy tropics. If we stick to doing what we do best – adaptation – we will continue to thrive. We must be prepared not only for global warming, but also for global cooling, which will surely occur as our present warm Holocene draws to its inevitable end.

Human health and that of the planet depends on balancing productivity and development with conservation and environmental protection. Only developed countries with people lifted out of poverty can afford to produce clean energy, protect the environment, put power lines underground, construct buildings with 5-star energy ratings and use efficient lighting/appliances to minimize energy and water use, provide adequate safe water supplies and effective public health measures to control communicable diseases. It is vital that governments focus on real pollutants, not imagined ones, and that they avoid using climate change as a scapegoat for failure to implement sound public health policies and proven preventive measures. Misguided climate action can be worse than unmitigated climate change.

Urban design can be improved to reduce urban heat, and to encourage health-promoting walking and cycling. Smoggy cities could also encourage a switch to electric vehicles, but not with generous taxpayer-funded subsidies. Energy costs need to be kept as low as possible, especially in cold climates, so that poor people can afford to keep warm in winter. Fossil fuels, including coal, will continue to have an important role to play in advancing civilization and human health over the 21st century. Our focus should be on conservation and health-promoting activities rather than on CO_2 and climate change. Unmitigated warming this century is likely to be more beneficial than harmful for humanity and the planet.

The 2014 IPCC Summary for Policymakers nicely summed it up: "The most effective vulnerability reduction measures for health in the near term are programs that implement and improve basic public health measures such as provision of clean water and sanitation, secure essential health care including vaccination and child health services, increase capacity for disaster preparedness and response, and alleviate poverty (*very high confidence*)." [389]

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