## **Nuclear War- Extinction**

#### Nuclear war is an existential risk- blast would kill millions; disease, starvation and nuclear winter would risk wipeout

(John Loretz is the Program Director of International Physicians for the Prevention of Nuclear War and an editor of MCS and Maria Valenti is the coordinator of Aiming for Prevention, the International Physician for the Prevention of Nuclear War’s campaign to prevent small arms violence, “A medical appeal for a nuclear-weapons-free world; speaking out against violence”, Medicine, Conflict and Survival, 6/26/2009, <http://www.tandfonline.com/doi/pdf/10.1080/13623690903068748>)

Dear Presidents Obama and Medvedev: For more than 60 years the threat of nuclear annihilation has hung over humanity. We write to you now with great hope that you will seize the opportunity created by your recent elections to address deﬁnitively this gravest threat to human survival. The United States and Russia continue to possess enormous arsenals of nuclear weapons originally built to ﬁght the Cold War. If these instruments of mass extermination ever had a purpose, that purpose ended 20 years ago. Yet the US and Russia still have more than 20,000 nuclear warheads. Most dangerously more than 2,300 of them are maintained on high alert status. They are mounted on missiles and can be launched in a matter of minutes, destroying cities in each other’s countries a half hour later. A study published in 2002 showed that if only 300 of the weapons in the Russian arsenal attacked targets in American cities, 90 million people would die in the ﬁrst half hour. A comparable US attack on Russia would produce 172 J. Loretz and M. Valenti Downloaded by [Dartmouth College Library] at 18:54 02 August 2012 similar devastation. Furthermore, these attacks would destroy the entire economic, communications, and transportation infrastructure on which the rest of the population depend for survival. In the ensuing months the vast majority of people who survived the initial attacks in both of your countries would die of disease, exposure, and starvation. But the destruction of Russia and the United States is only part of the story. An attack of this magnitude would lift millions of tons of soot and dust into the upper levels of the atmosphere blocking out sunlight and dropping temperatures across the globe. In fact, if the whole of your strategic arsenals were involved, average surface temperature would fall to levels not seen on Earth since the depth of the last ice age 18,000 years ago. Agriculture would stop, ecosystems would collapse, and many, many species, perhaps even our own, would become extinct. Even a limited war involving only 100 Hiroshima-sized bombs would cause enough climate disruption to provoke a global famine that we have reason to fear could kill up to one billion people. Such a war might involve other nuclear weapons states, such as India or Pakistan. This ﬁnding underlines the urgency of getting all nuclear weapons states to renounce their nuclear arsenals. It also underlines the urgency of ‘getting to zero’ – eliminating all of your nuclear weapons, since even 50 weapons in each of the US and Russian arsenals would pose a threat to the entire globe.

#### Humans existence is fragile; nuclear war could wipe us out

(Bruce E. Tonn, Department of Political Science at the University of Tennessee, “Futures Sustainability”, Futures, 9/2007, <http://www.sciencedirect.com/science/article/pii/S0016328707000730>)

All of the threats mentioned above at least indirectly threaten humans if one believes that a massive extinction of species would also lead to the extinction of humans. Many of these threats also directly threaten humans. Nuclear war, collisions with asteroids, and massive volcanic eruptions could cause widespread loss of human life. Runaway global warming and reduction of oxygen in the atmosphere could almost certainly lead to the extinction of humans. Human existence is also more fragile in some ways than is earth-life taken as a whole. One reason is because H. sapiens are a comparatively homogeneous species. There is not much difference in the DNA among humans, at least when compared to differences in among other primates and many other species. This makes humans more vulnerable to exceedingly virulent pathogens, for example, because human DNA may not have enough variation to survive some types of super-germs. Our reproductive systems may also not have enough variation to survive the toxic soup of chemically persistent endocrine disrupters that are continually being emitted into the environment. Some risks are peculiar to our species. Humans have the capability and the willingness to kill each other in large numbers. Our scientific and technological curiosities have come under scrutiny from worriers: we might unleash an unstoppable nano-fabricator, the so called ‘grey goo scenario’ or conduct a high energy physics experiment that will warp space-time so much that the earth will be destroyed [[21]](http://www.sciencedirect.com/science/article/pii/S0016328707000730#bib21). We also have the psychology to commit suicide, despite a strong innate will to survive. Some speculate that conditions on earth could become so unbearable that humans could collectively decide to commit mass suicide. We could also simply dwindle way if people decide to stop having children. We are already seeing the beginnings of this phenomenon in several European countries. Probably few if any threats listed above are capable of causing the extinction of humans by themselves. For example, it is unlikely that a nuclearwar could kill all humans on the planet. Additionally, large numbers of healthy individuals could be quarantined if deadly pathogens became rampant. However, an unlikely sequence of events certainly has the potential to do so and it is these sequences of events that need to be assessed and dealt with.

## Nuclear War- Not Existential

#### Only a combination of threats threatens human existence- nuclear war alone is unlikely

(Bruce E. Tonn, Department of Political Science at the University of Tennessee, “Futures Sustainability”, Futures, 9/2007, <http://www.sciencedirect.com/science/article/pii/S0016328707000730>)

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#### Nuclear war is not existential- high threshold

(Robin Hanson, Department of Economics at George Mason University, “Catastrophe, Social Collapse, and Human Extinction”, 8/07, <http://webcache.googleusercontent.com/search?q=cache:http://hanson.gmu.edu/collapse.pdf>)

How much should we worry about even larger disasters, triggered by disruptions several times stronger than ones that can kill a large fraction of humanity? Well, if we only cared about the expected number of people killed due to an event, then we would not care that much whether 99% or 99.9% of the population was killed. In this case, for low power disasters we would care the most about events large enough to kill roughly half of the population; our concern would fall away slowly as we considered smaller events, and fall away quickly as we considered larger events. A disaster large enough to kill off humanity, however, should be of special concern. Such a disaster would prevent the existence of all future generations of humanity. Of course it is possible that humanity was about to end in any case, and it is also possible that without humans within a few million years some other mammal species on Earth would evolve to produce a society we would respect. Nevertheless, since it is also possible that neither of these things would happen, the complete destruction of humanity must be considered a great harm, above and beyond the number of humans killed in such an event. It seems that groups of about seventy people colonized both Polynesia and the New World (Murray-McIntosh, Scrimshaw, Hatfield, & Penny, 1998; Hey, 2005). So let us assume, as a reference point for analysis, that the survival of humanity requires that one hundred humans remain, relatively close to one another, after a disruption and its resulting social collapse. With a healthy enough environment, one hundred connected humans might successfully adopt a hunter-gatherer lifestyle. If they were in close enough contact, and had enough resources to help them through a transition period, they might maintain a sufficiently diverse gene pool, and slowly increase their capabilities until they could support farming. Once they could communicate to share innovations and grow at the rate that our farming ancestors grew, humanity should return to our population and productivity level within twenty thousand years. (The fact that we have used up some natural resources this time 7

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Figure 1: A Soft Cutoff Power Law Scenario around would probably matter little, as growth rates do not seem to depend much on natural resource availability. ) With less than one hundred survivors near each other, on the other hand, we assume humanity would become extinct within a few generations.

## Nuclear War- Likely

#### New and dangerous era distinguishes from Cold War era- terrorists and new nuclear states

(Mr. Shultz, a distinguished fellow at the Hoover Institution at Stanford, was secretary of

state from 1982 to 1989. Mr. Perry was secretary of defense from 1994 to 1997. Mr.

Kissinger, chairman of Kissinger Associates, was secretary of state from 1973 to 1977.

Mr. Nunn is former chairman of the Senate Armed Services Committee, “A World Free of Nuclear Weapons”, The Wall Street Journal, 1/4/07, <http://disarmament.nrpa.no/wp-content/uploads/2008/02/A_WORLD_FREE.pdf>)

Nuclear weapons were essential to maintaining international security during the Cold War because they were a means of deterrence. The end of the Cold War made the doctrine of mutual Soviet-American deterrence obsolete. Deterrence continues to be a relevant consideration for many states with regard to threats from other states. But reliance on nuclear weapons for this purpose is becoming increasingly hazardous and decreasingly effective. North Korea's recent nuclear test and Iran's refusal to stop its program to enrich uranium - - potentially to weapons grade -- highlight the fact that the world is now on the precipice of a new and dangerous nuclear era. Most alarmingly, the likelihood that non-state terrorists will get their hands on nuclear weaponry is increasing. In today's war waged on world order by terrorists, nuclear weapons are the ultimate means of mass devastation. And non-state terrorist groups with nuclear weapons are conceptually outside the bounds of a deterrent strategy and present difficult new security challenges. Apart from the terrorist threat, unless urgent new actions are taken, the U.S. soon will be compelled to enter a new nuclear era that will be more precarious, psychologically disorienting, and economically even more costly than was Cold War deterrence. It is far from certain that we can successfully replicate the old Soviet-American "mutually assured destruction" with an increasing number of potential nuclear enemies world-wide without dramatically increasing the risk that nuclear weapons will be used. New nuclear states do not have the benefit of years of step-by-step safeguards put in effect during the Cold War to prevent nuclear accidents, misjudgments or unauthorized launches. The United States and the Soviet Union learned from mistakes that were less than fatal. Both countries were diligent to ensure that no nuclear weapon was used during the Cold War by design or by accident. Will new nuclear nations and the world be as fortunate in the next 50 years as we were during the Cold War? Leaders addressed this issue in earlier times. In his "Atoms for Peace" address to the United Nations in 1953, Dwight D. Eisenhower pledged America's "determination to help solve the fearful atomic dilemma -- to devote its entire heart and mind to find the way by which the miraculous inventiveness of man shall not be dedicated to his death, but 2 consecrated to his life." John F. Kennedy, seeking to break the logjam on nuclear disarmament, said, "The world was not meant to be a prison in which man awaits his execution." Rajiv Gandhi, addressing the U.N. General Assembly on June 9, 1988, appealed, "Nuclear war will not mean the death of a hundred million people. Or even a thousand million. It will mean the extinction of four thousand million: the end of life as we know it on our planet earth. We come to the United Nations to seek your support. We seek your support to put a stop to this madness." Ronald Reagan called for the abolishment of "all nuclear weapons," which he considered to be "totally irrational, totally inhumane, good for nothing but killing, possibly destructive of life on earth and civilization." Mikhail Gorbachev shared this vision, which had also been expressed by previous American presidents. Although Reagan and Mr. Gorbachev failed at Reykjavik to achieve the goal of an agreement to get rid of all nuclear weapons, they did succeed in turning the arms race on its head. They initiated steps leading to significant reductions in deployed long- and intermediate-range nuclear forces, including the elimination of an entire class of threatening missiles. What will it take to rekindle the vision shared by Reagan and Mr. Gorbachev? Can a world-wide consensus be forged that defines a series of practical steps leading to major reductions in the nuclear danger? There is an urgent need to address the challenge posed by these two questions.

#### Nuclear war likely- US and Russia still have adequate nuclear arsenals on high-alert

(John Loretz is the Program Director of International Physicians for the Prevention of Nuclear War and an editor of MCS and Maria Valenti is the coordinator of Aiming for Prevention, the International Physician for the Prevention of Nuclear War’s campaign to prevent small arms violence, “A medical appeal for a nuclear-weapons-free world; speaking out against violence”, Medicine, Conflict and Survival, 6/26/2009, <http://www.tandfonline.com/doi/pdf/10.1080/13623690903068748>)

Dear Presidents Obama and Medvedev: For more than 60 years the threat of nuclear annihilation has hung over humanity. We write to you now with great hope that you will seize the opportunity created by your recent elections to address deﬁnitively this gravest threat to human survival. The United States and Russia continue to possess enormous arsenals of nuclear weapons originally built to ﬁght the Cold War. If these instruments of mass extermination ever had a purpose, that purpose ended 20 years ago. Yet the US and Russia still have more than 20,000 nuclear warheads. Most dangerously more than 2,300 of them are maintained on high alert status. They are mounted on missiles and can be launched in a matter of minutes, destroying cities in each other’s countries a half hour later. A study published in 2002 showed that if only 300 of the weapons in the Russian arsenal attacked targets in American cities, 90 million people would die in the ﬁrst half hour. A comparable US attack on Russia would produce 172 J. Loretz and M. Valenti Downloaded by [Dartmouth College Library] at 18:54 02 August 2012 similar devastation. Furthermore, these attacks would destroy the entire economic, communications, and transportation infrastructure on which the rest of the population depend for survival. In the ensuing months the vast majority of people who survived the initial attacks in both of your countries would die of disease, exposure, and starvation. But the destruction of Russia and the United States is only part of the story. An attack of this magnitude would lift millions of tons of soot and dust into the upper levels of the atmosphere blocking out sunlight and dropping temperatures across the globe. In fact, if the whole of your strategic arsenals were involved, average surface temperature would fall to levels not seen on Earth since the depth of the last ice age 18,000 years ago. Agriculture would stop, ecosystems would collapse, and many, many species, perhaps even our own, would become extinct. Even a limited war involving only 100 Hiroshima-sized bombs would cause enough climate disruption to provoke a global famine that we have reason to fear could kill up to one billion people. Such a war might involve other nuclear weapons states, such as India or Pakistan. This ﬁnding underlines the urgency of getting all nuclear weapons states to renounce their nuclear arsenals. It also underlines the urgency of ‘getting to zero’ – eliminating all of your nuclear weapons, since even 50 weapons in each of the US and Russian arsenals would pose a threat to the entire globe.

#### Unstable regions risk escalating to nuclear war

(Alan Robock is professor of climatology at Rutgers University and associate director of the school's Center for Environmental Prediction, where he studies many aspects of climate change. He is a fellow of the American Meteorological Society and a participant in the Intergovernmental Panel on Climate Change. Owen Brian Toon is chair of the department of atmospheric and oceanic sciences at the University of Colorado at Boulder and a fellow of the Laboratory for Atmospheric and Space Physics there. He is a fellow of the American Meteorological Society and the American Geophysical Union, “Long Nuclear War, Global Suffering”, Scientific American, 1/10, <http://www.nature.com/scientificamerican/journal/v302/n1/full/scientificamerican0110-74.html>)

People have several incorrect impressions about nuclear winter. One is that the climatic effects were disproved; this is just not true [see sidebar on page 78]. Another is that the world would experience “nuclear autumn” instead of winter. But our new calculations show that the climate effects even of a regional conflict would be widespread and severe. The models and computers used in the 1980s were not able to simulate the lofting and persistence of the smoke or the long time it would take oceans to warm back up as the smoke eventually dissipated; current models of a full-scale nuclear exchange predict a nuclear winter, not a nuclear fall. Another misimpression is that the problem, even if it existed, has been solved by the end of the nuclear arms race. In fact, a nuclear winter could readily be produced by the American and Russian nuclear arsenals that are slated to remain in 2012. Furthermore, the increasing number of nuclear states raises the chances of a war starting deliberately or by accident. For example, North Korea has threatened war should the world stop its ships and inspect them for transporting nuclear materials. Fortunately, North Korea does not now have a usable nuclear arsenal, but it may have one capable of global reach in the near future. Some extremist leaders in India advocated attacking Pakistan with nuclear weapons following recent terrorist attacks on India. Because India could rapidly overrun Pakistan with conventional forces, it would be conceivable for Pakistan to attack India with nuclear weapons if it thought that India was about to go on the offensive. Iran has threatened to destroy Israel, already a nuclear power, which in turn has vowed never to allow Iran to become a nuclear state. Each of these examples represent countries that imagine their existence to be threatened completely and with little warning. These points of conflict have the potential to erupt suddenly. The first nuclear war so shocked the world that in spite of the massive buildup of these weapons since then, they have never been used again. But the only way to eliminate the possibility of climatic catastrophe is to eliminate the weapons. Rapid reduction of the American and Russian arsenals would set an example for the rest of the world that nuclear weapons cannot be used and are not needed.

#### Proliferation and instability make nuclear war likely- only abolition of nukes can solve

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Under the Strategic Offensive Reductions Treaty, the U.S. and Russia both committed to reduce deployed strategic nuclear warheads down to between 1,700 to 2,200 apiece by the end of 2012. In July 2009 President Barack Obama and Russian president Dmitry Medvedev agreed to drop that range further, to 1,500 to 1,675 by 2016. Although smaller strategic arsenals are to be commended, our new results show that even the lower counts are far more than enough to destroy agriculture worldwide, as is a regional nuclear war. If this mother lode of weapons were used against urban targets, hundreds of millions of people would be killed and a whopping 180 Tg of smoke would be sent into the global stratosphere. Average temperatures would remain below freezing even in the summer for several years in major agricultural regions. Even the warheads on one missile-carrying submarine could produce enough smoke to create a global environmental disaster. The combination of nuclear proliferation, political instability and urban demographics may constitute one of the greatest dangers to the stability of society since the dawn of humans. Only abolition of nuclear weapons will prevent a potential nightmare. Immediate reduction of U.S. and Russian arsenals to the same levels as other nuclear powers (a few hundred) would maintain their deterrence, reduce the possibility of nuclear winter and encourage the rest of the world to continue to work toward the goal of elimination.

#### India and Pakistan instability risks nuclear war- nuclear arsenals and Pakistani attack incentive

(Alan Robock is professor of climatology at Rutgers University and associate director of the school's Center for Environmental Prediction, where he studies many aspects of climate change. He is a fellow of the American Meteorological Society and a participant in the Intergovernmental Panel on Climate Change. Owen Brian Toon is chair of the department of atmospheric and oceanic sciences at the University of Colorado at Boulder and a fellow of the Laboratory for Atmospheric and Space Physics there. He is a fellow of the American Meteorological Society and the American Geophysical Union, “Long Nuclear War, Global Suffering”, Scientific American, 1/10, <http://www.nature.com/scientificamerican/journal/v302/n1/full/scientificamerican0110-74.html>)

By deploying modern computers and modern climate models, the two of us and our colleagues have shown that not only were the ideas of the 1980s correct but the effects would last for at least 10 years, much longer than previously thought. And by doing calculations that assess decades of time, only now possible with fast, current computers, and by including in our calculations the oceans and the entire atmosphere—also only now possible—we have found that the smoke from even a regional war would be heated and lofted by the sun and remain suspended in the upper atmosphere for years, continuing to block sunlight and to cool the earth. India and Pakistan, which together have more than 100 nuclear weapons, may be the most worrisome adversaries capable of a regional nuclear conflict today. But other countries besides the U.S. and Russia (which have thousands) are well endowed: China, France and the U.K. have hundreds of nuclear warheads; Israel has more than 80, North Korea has about 10 and Iran may well be trying to make its own. In 2004 this situation prompted one of us (Toon) and later Rich Turco of the University of California, Los Angeles, both veterans of the 1980s investigations, to begin evaluating what the global environmental effects of a regional nuclear war would be and to take as our test case an engagement between India and Pakistan. The latest estimates by David Albright of the Institute for Science and International Security and by Robert S. Norris of the Natural Resources Defense Council are that India has 50 to 60 assembled weapons (with enough plutonium for 100) and that Pakistan has 60 weapons. Both countries continue to increase their arsenals. Indian and Pakistani nuclear weapons tests indicate that the yield of the warheads would be similar to the 15-kiloton explosive yield (equivalent to 15,000 tons of TNT) of the bomb the U.S. used on Hiroshima. Toon and Turco, along with Charles Bardeen, now at the National Center for Atmospheric Research, modeled what would happen if 50 Hiroshima-size bombs were dropped across the highest population-density targets in Pakistan and if 50 similar bombs were also dropped across India. Some people maintain that nuclear weapons would be used in only a measured way. But in the wake of chaos, fear and broken communications that would occur once a nuclear war began, we doubt leaders would limit attacks in any rational manner. This likelihood is particularly true for Pakistan, which is small and could be quickly overrun in a conventional conflict. Peter R. Lavoy of the Naval Postgraduate School, for example, has analyzed the ways in which a conflict between India and Pakistan might occur and argues that Pakistan could face a decision to use all its nuclear arsenal quickly before India swamps its military bases with traditional forces. http://www.nature.com/rj/images/quoteleft.gifPakistan could elect to use its nuclear arsenal before India swamps its military bases.http://www.nature.com/rj/images/quoteright.gif

## Nuclear War- Warming

#### Studies confirm nuclear war causes nuclear winter

(Alan Robock is professor of climatology at Rutgers University and associate director of the school's Center for Environmental Prediction, where he studies many aspects of climate change. He is a fellow of the American Meteorological Society and a participant in the Intergovernmental Panel on Climate Change. Owen Brian Toon is chair of the department of atmospheric and oceanic sciences at the University of Colorado at Boulder and a fellow of the Laboratory for Atmospheric and Space Physics there. He is a fellow of the American Meteorological Society and the American Geophysical Union, “Long Nuclear War, Global Suffering”, Scientific American, 1/10, <http://www.nature.com/scientificamerican/journal/v302/n1/full/scientificamerican0110-74.html>)

Twenty-five years ago international teams of scientists showed that a nuclear war between the U.S. and the Soviet Union could produce a “nuclear winter.” The smoke from vast fires started by bombs dropped on cities and industrial areas would envelop the planet and absorb so much sunlight that the earth's surface would get cold, dark and dry, killing plants worldwide and eliminating our food supply. Surface temperatures would reach winter values in the summer. International discussion about this prediction, fueled largely by astronomer Carl Sagan, forced the leaders of the two superpowers to confront the possibility that their arms race endangered not just themselves but the entire human race. Countries large and small demanded disarmament. Nuclear winter became an important factor in ending the nuclear arms race. Looking back later, in 2000, former Soviet Union leader Mikhail S. Gorbachev observed, “Models made by Russian and American scientists showed that a nuclear war would result in a nuclear winter that would be extremely destructive to all life on earth; the knowledge of that was a great stimulus to us, to people of honor and morality, to act.” Why discuss this topic now that the cold war has ended? Because as other nations continue to acquire nuclear weapons, smaller, regional nuclear wars could create a similar global catastrophe. New analyses reveal that a conflict between India and Pakistan, for example, in which 100 nuclear bombs were dropped on cities and industrial areas—only 0.4 percent of the world's more than 25,000 warheads—would produce enough smoke to cripple global agriculture. A regional war could cause widespread loss of life even in countries far away from the conflict.

#### India and Pakistan instability risks nuclear winter-

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By deploying modern computers and modern climate models, the two of us and our colleagues have shown that not only were the ideas of the 1980s correct but the effects would last for at least 10 years, much longer than previously thought. And by doing calculations that assess decades of time, only now possible with fast, current computers, and by including in our calculations the oceans and the entire atmosphere—also only now possible—we have found that the smoke from even a regional war would be heated and lofted by the sun and remain suspended in the upper atmosphere for years, continuing to block sunlight and to cool the earth. India and Pakistan, which together have more than 100 nuclear weapons, may be the most worrisome adversaries capable of a regional nuclear conflict today. But other countries besides the U.S. and Russia (which have thousands) are well endowed: China, France and the U.K. have hundreds of nuclear warheads; Israel has more than 80, North Korea has about 10 and Iran may well be trying to make its own. In 2004 this situation prompted one of us (Toon) and later Rich Turco of the University of California, Los Angeles, both veterans of the 1980s investigations, to begin evaluating what the global environmental effects of a regional nuclear war would be and to take as our test case an engagement between India and Pakistan.

#### Nuclear winter creates cooling effect, ozone damage, less sunlight and precipitation

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Obviously, we hope the number of nuclear targets in any future war will be zero, but policy makers and voters should know what is possible. Toon and Turco found that more than 20 million people in the two countries could die from the blasts, fires and radioactivity—a horrible slaughter. But the investigators were shocked to discover that a tremendous amount of smoke would be generated, given the megacities in the two countries, assuming each fire would burn the same area that actually did burn in Hiroshima and assuming an amount of burnable material per person based on various studies. They calculated that the 50 bombs exploded in Pakistan would produce three teragrams of smoke, and the 50 bombs hitting India would generate four (one teragram equals a million metric tons). Satellite observations of actual forest fires have shown that smoke can be lofted up through the troposphere (the bottom layer of the atmosphere) and sometimes then into the lower stratosphere (the layer just above, extending to about 30 miles). Toon and Turco also did some “back of the envelope” calculations of the possible climate impact of the smoke should it enter the stratosphere. The large magnitude of such effects made them realize they needed help from a climate modeler. It turned out that one of us (Robock) was already working with Luke Oman, now at the NASA Goddard Space flight Center, who was finishing his Ph.D. at Rutgers University on the climatic effects of volcanic eruptions, and with Georgiy L. Stenchikov, also at Rutgers and an author of the first Russian work on nuclear winter. They developed a climate model that could be used fairly easily for the nuclear blast calculations. Robock and his colleagues, being conservative, put five teragrams of smoke into their modeled upper troposphere over India and Pakistan on an imaginary May 15. The model calculated how winds would blow the smoke around the world and how the smoke particles would settle out from the atmosphere. The smoke covered all the continents within two weeks. The black, sooty smoke absorbed sunlight, warmed and rose into the stratosphere. Rain never falls there, so the air is never cleansed by precipitation; particles very slowly settle out by falling, with air resisting them. Soot particles are small, with an average diameter of only 0.1 micron, and so drift down very slowly. They also rise during the daytime as they are heated by the sun, repeatedly delaying their elimination. The calculations showed that the smoke would reach far higher into the upper stratosphere than the sulfate particles that are produced by episodic volcanic eruptions. Sulfate particles are transparent and absorb much less sunlight than soot and are also bigger, typically 0.5 μm. The volcanic particles remain airborne for about two years, but smoke from nuclear fires would last a decade.The climatic response to the smoke was surprising. Sunlight was immediately reduced, cooling the planet to temperatures lower than any experienced for the past 1,000 years. The global average cooling, of about 1.25 degrees Celsius (2.3 degrees Fahrenheit), lasted for several years, and even after 10 years the temperature was still 0.5 degree C colder than normal. The models also showed a 10 percent reduction in precipitation worldwide. Precipitation, river flow and soil moisture all decreased because blocking sunlight reduces evaporation and weakens the hydrologic cycle. Drought was largely concentrated in the lower latitudes, however, because global cooling would retard the Hadley air circulation pattern in the tropics, which produces a large fraction of global precipitation. In critical areas such as the Asian monsoon regions, rainfall dropped by as much as 40 percent. The cooling might not seem like much, but even a small dip can cause severe consequences. Cooling and diminished sunlight would, for example, shorten growing seasons in the midlatitudes. More insight into the effects of cooling came from analyses of the aftermaths of massive volcanic eruptions. Every once in a while such eruptions produce temporary cooling for a year or two. The largest of the past 500 years, the 1815 Tambora eruption in Indonesia, blotted the sun and produced global cooling of about 0.5 degree C for a year; 1816 became known as “The Year without a Summer” or “Eighteen Hundred and Froze to Death.” In New England, although the average summer temperature was lowered only a few degrees, crop-killing frosts occurred in every month. After the first frost, farmers replanted crops, only to see them killed by the next frost. The price of grain skyrocketed, the price of livestock plummeted as farmers sold the animals they could not feed, and a mass migration began from New England to the Midwest, as people followed reports of fertile land there. In Europe the weather was so cold and gloomy that the stock market collapsed, widespread famines occurred and 18-year-old Mary Shelley was inspired to write Frankenstein. Certain strains of crops, such as winter wheat, can withstand lower temperatures, but a lack of sunlight inhibits their ability to grow. In our scenario, daylight would filter through the high smoky haze, but on the ground every day would seem to be fully overcast. Agronomists and farmers could not develop the necessary seeds or adjust agricultural practices for the radically different conditions unless they knew ahead of time what to expect. In addition to the cooling, drying and darkness, extensive ozone depletion would result as the smoke heated the stratosphere; reactions that create and destroy ozone are temperature-dependent. Michael J. Mills of the University of Colorado at Boulder ran a completely separate climate model from Robock's but found similar results for smoke lofting and stratospheric temperature changes. He concluded that although surface temperatures would cool by a small amount, the stratosphere would be heated by more than 50 degrees C, because the black smoke particles absorb sunlight. This heating, in turn, would modify winds in the stratosphere, which would carry ozone-destroying nitrogen oxides into its upper reaches. Together the high temperatures and nitrogen oxides would reduce ozone to the same dangerous levels we now experience below the ozone hole above Antarctica every spring. Ultraviolet radiation on the ground would increase significantly because of the diminished ozone. Less sunlight and precipitation, cold spells, shorter growing seasons and more ultraviolet radiation would all reduce or eliminate agricultural production. Notably, cooling and ozone loss would be most profound in middle and high latitudes in both hemispheres, whereas precipitation declines would be greatest in the tropics. The specific damage inflicted by each of these environmental changes would depend on particular crops, soils, agricultural practices and regional weather patterns, and no researchers have completed detailed analyses of such agricultural responses. Even in normal times, however, feeding the growing human population depends on transferring food across the globe to make up for regional farming deficiencies caused by drought and seasonal weather changes. The total amount of grain stored on the planet today would feed the earth's population for only about two months [see “Could Food Shortages Bring Down Civilization?” by Lester R. Brown; SCIENTIFIC AMERICAN, May]. Most cities and countries have stockpiled food supplies for just a very short period, and food shortages (as well as rising prices) have increased in recent years. A nuclear war could trigger declines in yield nearly everywhere at once, and a worldwide panic could bring the global agricultural trading system to a halt, with severe shortages in many places. Around one billion people worldwide who now live on marginal food supplies would be directly threatened with starvation by a nuclear war between India and Pakistan or between other regional nuclear powers.

#### Nuclear war with current arsenals could cause substantial environmental harm

(Alan Robock is professor of climatology at Rutgers University and associate director of the school's Center for Environmental Prediction, where he studies many aspects of climate change. He is a fellow of the American Meteorological Society and a participant in the Intergovernmental Panel on Climate Change. Owen Brian Toon is chair of the department of atmospheric and oceanic sciences at the University of Colorado at Boulder and a fellow of the Laboratory for Atmospheric and Space Physics there. He is a fellow of the American Meteorological Society and the American Geophysical Union, “Long Nuclear War, Global Suffering”, Scientific American, 1/10, <http://www.nature.com/scientificamerican/journal/v302/n1/full/scientificamerican0110-74.html>)

Under the Strategic Offensive Reductions Treaty, the U.S. and Russia both committed to reduce deployed strategic nuclear warheads down to between 1,700 to 2,200 apiece by the end of 2012. In July 2009 President Barack Obama and Russian president Dmitry Medvedev agreed to drop that range further, to 1,500 to 1,675 by 2016. Although smaller strategic arsenals are to be commended, our new results show that even the lower counts are far more than enough to destroy agriculture worldwide, as is a regional nuclear war. If this mother lode of weapons were used against urban targets, hundreds of millions of people would be killed and a whopping 180 Tg of smoke would be sent into the global stratosphere. Average temperatures would remain below freezing even in the summer for several years in major agricultural regions. Even the warheads on one missile-carrying submarine could produce enough smoke to create a global environmental disaster. The combination of nuclear proliferation, political instability and urban demographics may constitute one of the greatest dangers to the stability of society since the dawn of humans. Only abolition of nuclear weapons will prevent a potential nightmare. Immediate reduction of U.S. and Russian arsenals to the same levels as other nuclear powers (a few hundred) would maintain their deterrence, reduce the possibility of nuclear winter and encourage the rest of the world to continue to work toward the goal of elimination.

#### Environmental effects of nuclear weapons- agriculture, forests, water, climate change

(Abeer Majeed, “The Impact of Militarism on the Environment”, Research report for Physicians for Global Survival, 2/04, <http://weaponspollute.org/wp-content/uploads/2010/12/militarism_environment_web.pdf>)

 Climatic Effects— The potential effect a nuclear exchange could have on climate was first presented in 1983 and is most commonly known as “Nuclear Winter”. A large-scale nuclear exchange between nations could conceivably have a catastrophic global effect on climate. It would expel large enough quantities of dust and smoke into the atmosphere from resulting firestorms after the blast, so as to block sunlight for several months particularly in the northern hemisphere. The reduced ability of solar radiation to enter the atmosphere would result in reduced temperatures, destroying plant life and creating a subfreezing climate until the dust is dispersed. Damage to the ozone layer and the subsequent inability to screen out ultraviolet radiation would further harm the planet’s flora and fauna. In a commonly used scenario, a 6.5 thousand megaton (MT) exchange would inject 330-825 million tons (Tg) of particles and 180-300Tg of sooty smoke from fires into the atmosphere (Freedman 1995). Reflection by dust and absorption and reradiation by sooty smoke could reduce the amount of energy received at the planet’s surface by 90%. Additionally, it is estimated that a 6.5 thousand MT nuclear exchange would produce 36.9 Tg of gaseous NO, 225 Tg of CO and large emissions of sulfur oxides, hydrocarbons and other toxic substances; resulting in a 17% decrease in the concentration of stratospheric ozone but a potential increase in tropospheric ozone (Freedman 1995).Physicians for Global Survival The Impact of Militarism on the Environment 12

#### Even a limited nuclear exchange would cause significant cooling and long-term warming

(Mark Z. Jacobson, Professor of Civil and Environmental Engineering, Stanford,   
“Review of solutions to global warming, air pollution, and energy security”, Energy and Environmental Science, 6/12/08, <http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#tab4fna>)

Currently, about 30http://www.rsc.org/images/entities/char_2009.gif000 nuclear warheads exist worldwide, with 95% in the US and Russia, but enough refined and unrefined material to produce another 100http://www.rsc.org/images/entities/char_2009.gif000 weapons.[69](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#cit69) The explosion of fifty 15 kt nuclear devices (a total of 1.5 MT, or 0.1% of the yields proposed for a full-scale nuclear war) during a limited nuclear exchange in megacities could burn 63–313 Tg of fuel, adding 1–5 Tg of soot to the atmosphere, much of it to the stratosphere, and killing 2.6–16.7 million people.[68](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#cit68) The soot emissions would cause significant short- and medium-term regional cooling.[70](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#cit70) Despite short-term cooling, the CO2emissions would cause long-term warming, as they do with biomass burning.[62](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#cit62) The CO2 emissions from such a conflict are estimated here from the fuel burn rate and the carbon content of fuels. Materials have the following carbon contents: plastics, 38–92%; tires and other rubbers, 59–91%; synthetic fibers, 63–86%;[71](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#cit71) woody biomass, 41–45%; charcoal, 71%;[72](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#cit72) asphalt, 80%; steel, 0.05–2%. We approximate roughly the carbon content of all combustible material in a city as 40–60%. Applying these percentages to the fuel burn gives CO2 emissions during an exchange as 92–690 Tg CO2. The annual electricity production due to nuclear energy in 2005 was 2768 TWh yr−1. If one nuclear exchange as described above occurs over the next 30 yr, the net carbon emissions due to nuclear weapons proliferation caused by the expansion of nuclear energy worldwide would be 1.1–4.1 g CO2 kWh−1, where the energy generation assumed is the annual 2005 generation for nuclear power multiplied by the number of yr being considered. This emission rate depends on the probability of a nuclear exchange over a given period and the strengths of nuclear devices used. Here, we bound the probability of the event occurring over 30 yr as between 0 and 1 to give the range of possible emissions for one such event as 0 to 4.1 g CO2 kWh−1. This emission rate is placed in context in [Table 3](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#tab3).

#### Nuclear war and energy and CO2 emissions

(The Guardian, “The carbon footprint of nuclear war”, 1/2/09, The Guardian Environment Blog, <http://www.guardian.co.uk/environment/blog/2009/jan/02/nuclear-war-emissions>)

Just when you might have thought it was ethically sound to unleash a nuclear attack on a nearby city, along comes a pesky scientist and points out that atomic warfare is bad for the climate. According to a [new paper](http://www.rsc.org/delivery/_ArticleLinking/DisplayHTMLArticleforfree.cfm?JournalCode=EE&Year=2009&ManuscriptID=b809990c&Iss=Advance_Article#tab4fna)in the journal [Energy](http://www.guardian.co.uk/environment/energy) & Environmental Science, even a very limited nuclear exchange, using just a thousandth of the weaponry of a full-scale nuclear war, would cause up to 690m tonnes of CO2 to enter the atmosphere – more than UK's annual total. The upside (kind of) is that the conflict would also generate as much as 313m tonnes of soot. This would stop a great deal of sunlight reaching the earth, creating a significant regional cooling effect in the short and medium terms – just like when a major volcano erupts. Ultimately, though, the CO2 would win out and crank up global temperatures an extra few notches.

#### Nuclear war causes Ice Age- economic collapse, food shortages, extinction

(John Loretz is the Program Director of International Physicians for the Prevention of Nuclear War and an editor of MCS and Maria Valenti is the coordinator of Aiming for Prevention, the International Physician for the Prevention of Nuclear War’s campaign to prevent small arms violence, “A medical appeal for a nuclear-weapons-free world; speaking out against violence”, Medicine, Conflict and Survival, 6/26/2009, <http://www.tandfonline.com/doi/pdf/10.1080/13623690903068748>)

Dear Presidents Obama and Medvedev: For more than 60 years the threat of nuclear annihilation has hung over humanity. We write to you now with great hope that you will seize the opportunity created by your recent elections to address deﬁnitively this gravest threat to human survival. The United States and Russia continue to possess enormous arsenals of nuclear weapons originally built to ﬁght the Cold War. If these instruments of mass extermination ever had a purpose, that purpose ended 20 years ago. Yet the US and Russia still have more than 20,000 nuclear warheads. Most dangerously more than 2,300 of them are maintained on high alert status. They are mounted on missiles and can be launched in a matter of minutes, destroying cities in each other’s countries a half hour later. A study published in 2002 showed that if only 300 of the weapons in the Russian arsenal attacked targets in American cities, 90 million people would die in the ﬁrst half hour. A comparable US attack on Russia would produce 172 J. Loretz and M. Valenti Downloaded by [Dartmouth College Library] at 18:54 02 August 2012 similar devastation. Furthermore, these attacks would destroy the entire economic, communications, and transportation infrastructure on which the rest of the population depend for survival. In the ensuing months the vast majority of people who survived the initial attacks in both of your countries would die of disease, exposure, and starvation. But the destruction of Russia and the United States is only part of the story. An attack of this magnitude would lift millions of tons of soot and dust into the upper levels of the atmosphere blocking out sunlight and dropping temperatures across the globe. In fact, if the whole of your strategic arsenals were involved, average surface temperature would fall to levels not seen on Earth since the depth of the last ice age 18,000 years ago. Agriculture would stop, ecosystems would collapse, and many, many species, perhaps even our own, would become extinct. Even a limited war involving only 100 Hiroshima-sized bombs would cause enough climate disruption to provoke a global famine that we have reason to fear could kill up to one billion people. Such a war might involve other nuclear weapons states, such as India or Pakistan. This ﬁnding underlines the urgency of getting all nuclear weapons states to renounce their nuclear arsenals. It also underlines the urgency of ‘getting to zero’ – eliminating all of your nuclear weapons, since even 50 weapons in each of the US and Russian arsenals would pose a threat to the entire globe.

## Nuclear War- Terror

#### Destruction images from nuclear war may trigger terrorist response

(Kenneth E. Vail III, graduate student at University of Missouri-Columbia, Jamie Arndt, Professor at University of Missouri-Columbia, Matt Motyl, doctoral candidate in Psychology and Women’s Studies at University of Virginia, Tom Pyszczynski, Ph. D. and Distinguished Professor at University of Colorado at Colorado Springs, “The aftermath of destruction: Images of destroyed buildings increase support for war, dogmatism, and death thought accessibility “, Journal of Expirmental Social Psychology, 9/12, http://www.sciencedirect.com/science/article/pii/S0022103112000856)

The present research hypothesized that viewing destroyed buildings would enhance ideological certainty and violent worldview defensive attitudes because such scenes of destruction serve as a reminder of people's existential fragility, thereby triggering terror management efforts to believe more strongly in one's undying worldview beliefs and to aggressively protect those beliefs against threatening others. Four studies converged to support this analysis. Study 1 found that images of visible destruction increased death thought accessibility compared to images of intact buildings and construction sites. Study 2 showed that visible destruction increased the dogmatic certainty with which participants held their worldview beliefs. In Study 3, American students exposed to images of visible destruction were more supportive of military action against Iran. Study 4 conceptually replicated these findings and, importantly, also showed that the increase in death thought accessibility produced by viewing images of destroyed buildings uniquely mediated the increase in support for militarism. These findings were consistent across two distinct measures of thought accessibility and two separate measures of worldview defense. That the destruction conditions in Studies 1 and 4 affected more frequent completions of death-related word-fragments and led to quicker death word RT's (but not war or nation word RT's), respectively, provides converging evidence that visible destruction does, in fact, increase the accessibility of death-related thought. Second, the measures of anti-Iranian militarism and anti-terrorist militarism used in Studies 3 and 4 converge in showing that exposure to destruction does indeed increase worldview defense, and that this can take the form of increased support for intergroup violence. The present findings thus suggest that destroyed infrastructure can carry an existential signature, potentially serving as a day-to-day reminder of one's own transience and encouraging hostile worldview defenses. Given the specific worldview defensive attitudes studied here, the present findings can help to explain how exposure to visible destruction in certain geographical areas, such as in cities suffering severe urban deterioration, the sites of terrorist attacks or military strikes, or even natural disasters, might encourage ideological dogmatism and exacerbate harmful intergroup relations, potentially leading to even more violence and destruction. For example, in Jenin, a frequently shelled town known as the “capital of Palestinian martyrdom,” an Islamic Jihad spokesperson explained, “Look around and see how we live here, then maybe you will understand why there are always volunteers for martyrdom” ([Jacobson, 2001, par. 6](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0185)). Granting that the “broken windows” that characterize such poor living conditions can arouse a multitude of motivations, the present research points to terror management processes as one motivating force that can play an important role in fuelling hostile and violent intergroup relationships. Death, destruction, and terror management mechanisms As noted earlier, various studies have linked death thought accessibility to worldview defenses (see [Hayes et al., 2010](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0165)). Yet these lines of work have typically relied on an experimental causal chain strategy (see[Spencer, Zanna, & Fong, 2005](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0380)) of demonstrating in some studies that threats to the worldview increase the accessibility of death-related cognition (e.g., [Schimel et al., 2007](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0360)) and in other studies that defending the worldview after mortality salience reduces this accessibility (e.g., [Arndt et al., 1997](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0035)). Study 4 compliments and extends these approaches by showing that variations in the accessibility of death-related thought statistically mediate worldview defense (see also [Fransen et al., 2008](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0115)). Going further, Study 4 shows that the destruction images affected worldview defense through death thoughts only, and not through thoughts ofwar or national identity. This extends previous findings that terror management effects are specifically due to death thoughts and are not typically aroused by otherwise worrisome, value-focused, or aversive thoughts ([Greenberg et al., 1995](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0150); see also, [Pyszczynski, Greenberg, Solomon, & Maxfield, 2006](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0310)). The present research was designed to determine whether exposure to images of destroyed infrastructure increases death thought accessibility and therefore leads to ideological certainty and worldview defense, but these studies also raise some generative avenues for future research about the mechanism producing the link between exposure to visibly destroyed environments and death-related thought. We note three possibilities. The first is that scenes of destruction serve as symbolic reminders that one is ultimately vulnerable to existential threat. This entails that destruction, regardless of cause, will elicit death thought accessibility. The second is that visible destruction is a literal reminder of deadly events that may have led to the destruction. The implication of this possibility is that visible destruction would only elicit death thought if the scene is associated with deaths in some way, but would not arouse such cognitions if the scene were not associated with fatal or potentially fatal circumstances (e.g., normal decay of a building over time). The third possibility is that certain buildings can serve as cultural icons, the destruction of which would constitute a clear and direct threat to one's worldview. As individuals’ worldviews buffer against death thought accessibility (e.g., [Schimel et al., 2007](http://www.sciencedirect.com/science/article/pii/S0022103112000856#bb0360)), undermining such buffers via scenes of destroyed iconic buildings would thereby increase the accessibility of death-related thought. Although future research is needed to reveal whether and how each of these potential “trigger mechanisms” might play a role in different environments, the present demonstration of these basic processes has important implications for understanding the catalysts and consequences of existential motivation in everyday life. Destruction, reconstruction, and the malleability of terror management strategies In Studies 3 and 4, images of destruction increased the endorsement of militaristic defense of one's country, which is likely to exacerbate violent intergroup conflict.

#### Viewing destruction from nuclear war may trigger terrorist response

(Kenneth E. Vail III, graduate student at University of Missouri-Columbia, Jamie Arndt, Professor at University of Missouri-Columbia, Matt Motyl, doctoral candidate in Psychology and Women’s Studies at University of Virginia, Tom Pyszczynski, Ph. D. and Distinguished Professor at University of Colorado at Colorado Springs, “The aftermath of destruction: Images of destroyed buildings increase support for war, dogmatism, and death thought accessibility “, Journal of Expirmental Social Psychology, 9/12, <http://www.sciencedirect.com/science/article/pii/S0022103112000856>)

In sum, the present research uses TMT to offer a fresh perspective on some of the motivational implications of visibly destroyed physical surroundings. In these studies, exposure to images of destroyed buildings lead to greater death thought accessibility, which in turn strengthened people's dogmatic certainty about their cultural worldview beliefs. Images of destroyed buildings also boosted their support for violent military aggression against those who might threaten their way of life. These results bear important implications for modern ideological struggles and compromises, as well as for breaking the cycle of violent military and/or insurgent aggression.

## Nuclear War-Biodiversity

#### Environmental effects of nuclear weapons- agriculture, forests, water, climate

(Abeer Majeed, “The Impact of Militarism on the Environment”, Research report for Physicians for Global Survival, 2/04, http://weaponspollute.org/wp-content/uploads/2010/12/militarism\_environment\_web.pdf)

The Nuclear Age Peace Foundation has assessed the environmental consequences of nuclear weapons use and particularly exposure to ionizing radiation. Their analysis is presented here:  Agriculture— Although radiation occurs naturally in soil, excessive contamination of agricultural lands results in human exposure through ingestion of food. Radiation bioaccumulates and the most dangerous isotopes are those readily taken up by plants and passed on to animal products like milk and meat. Factors that further intensify exposure include: soil type, method of tilling crops, climate, season, and biological half-lives that determines amount taken up by plants or leached into the ground.  Forests— The deposition of radioactive material is higher in forests than in agricultural fields. Trees act like filters, resulting in increased absorption and retention of radioactive particles. Large doses of radiation kill trees, and the loss is increased by organic content and stage of forest growth. Flora such as lichen, mosses and mushrooms also often exhibit high concentrations of radioactive isotopes. The transfer of radioactive particles to wild game dwelling in a forest poses a high risk for those who are heavily dependant on this game as a primary food source.  Water Bodies— Contamination of water bodies can result from direct deposition from the air and discharge as effluent after a nuclear accident. It can also be caused indirectly by washout from the catchments of basins. Isotopes contaminating large bodies of water are quickly redistributed and tend to accumulate in bottom sediments, and within living organisms, plants and fish.  Climatic Effects— The potential effect a nuclear exchange could have on climate was first presented in 1983 and is most commonly known as “Nuclear Winter”. A large-scale nuclear exchange between nations could conceivably have a catastrophic global effect on climate. It would expel large enough quantities of dust and smoke into the atmosphere from resulting firestorms after the blast, so as to block sunlight for several months particularly in the northern hemisphere. The reduced ability of solar radiation to enter the atmosphere would result in reduced temperatures, destroying plant life and creating a subfreezing climate until the dust is dispersed. Damage to the ozone layer and the subsequent inability to screen out ultraviolet radiation would further harm the planet’s flora and fauna. In a commonly used scenario, a 6.5 thousand megaton (MT) exchange would inject 330-825 million tons (Tg) of particles and 180-300Tg of sooty smoke from fires into the atmosphere (Freedman 1995). Reflection by dust and absorption and reradiation by sooty smoke could reduce the amount of energy received at the planet’s surface by 90%. Additionally, it is estimated that a 6.5 thousand MT nuclear exchange would produce 36.9 Tg of gaseous NO, 225 Tg of CO and large emissions of sulfur oxides, hydrocarbons and other toxic substances; resulting in a 17% decrease in the concentration of stratospheric ozone but a potential increase in tropospheric ozone (Freedman 1995).Physicians for Global Survival The Impact of Militarism on the Environment 12 Table 2: Comparative damage to biota caused by nuclear bomb detonations in the troposphere or on the surface. Source: Modified from Weapons of Mass Destruction and the Environment, Westing 1977 Area suffering the given type of damage (ha) Tropospheric air burst Surface detonation Type of Damage 0.91 MT bomb 9.1 MT bomb 0.91 MT bomb 9.1 MT bomb Craterization by blast wave 0 0 12 57 90% of trees blown down by blast wave 14,100 82,000 9,040 52,500 Trees killed by nuclear radiation 648 1,250 12,800 63,800 All vegetation killed by nuclear radiation 312 759 2,830 12,100 Vegetation ignited by thermal radiation 33,300 183,000 21,300 117,000 Vertebrates killed by blast wave 591 2,740 332 1,540 Vertebrates killed by nuclear radiation 1,080 1,840 36,400 177,000 Vertebrates killed by thermal radiation 42,000 235,000 26,900 150,000 New developments—

## Nuclear War- Crops

#### Nuclear winter- smoke and dust create cooling effect, ozone damage, lack of sunlight

(Alan Robock is professor of climatology at Rutgers University and associate director of the school's Center for Environmental Prediction, where he studies many aspects of climate change. He is a fellow of the American Meteorological Society and a participant in the Intergovernmental Panel on Climate Change. Owen Brian Toon is chair of the department of atmospheric and oceanic sciences at the University of Colorado at Boulder and a fellow of the Laboratory for Atmospheric and Space Physics there. He is a fellow of the American Meteorological Society and the American Geophysical Union, “Long Nuclear War, Global Suffering”, Scientific American, 1/10, <http://www.nature.com/scientificamerican/journal/v302/n1/full/scientificamerican0110-74.html>)

Obviously, we hope the number of nuclear targets in any future war will be zero, but policy makers and voters should know what is possible. Toon and Turco found that more than 20 million people in the two countries could die from the blasts, fires and radioactivity—a horrible slaughter. But the investigators were shocked to discover that a tremendous amount of smoke would be generated, given the megacities in the two countries, assuming each fire would burn the same area that actually did burn in Hiroshima and assuming an amount of burnable material per person based on various studies. They calculated that the 50 bombs exploded in Pakistan would produce three teragrams of smoke, and the 50 bombs hitting India would generate four (one teragram equals a million metric tons). Satellite observations of actual forest fires have shown that smoke can be lofted up through the troposphere (the bottom layer of the atmosphere) and sometimes then into the lower stratosphere (the layer just above, extending to about 30 miles). Toon and Turco also did some “back of the envelope” calculations of the possible climate impact of the smoke should it enter the stratosphere. The large magnitude of such effects made them realize they needed help from a climate modeler. It turned out that one of us (Robock) was already working with Luke Oman, now at the NASA Goddard Space flight Center, who was finishing his Ph.D. at Rutgers University on the climatic effects of volcanic eruptions, and with Georgiy L. Stenchikov, also at Rutgers and an author of the first Russian work on nuclear winter. They developed a climate model that could be used fairly easily for the nuclear blast calculations. Robock and his colleagues, being conservative, put five teragrams of smoke into their modeled upper troposphere over India and Pakistan on an imaginary May 15. The model calculated how winds would blow the smoke around the world and how the smoke particles would settle out from the atmosphere. The smoke covered all the continents within two weeks. The black, sooty smoke absorbed sunlight, warmed and rose into the stratosphere. Rain never falls there, so the air is never cleansed by precipitation; particles very slowly settle out by falling, with air resisting them. Soot particles are small, with an average diameter of only 0.1 micron, and so drift down very slowly. They also rise during the daytime as they are heated by the sun, repeatedly delaying their elimination. The calculations showed that the smoke would reach far higher into the upper stratosphere than the sulfate particles that are produced by episodic volcanic eruptions. Sulfate particles are transparent and absorb much less sunlight than soot and are also bigger, typically 0.5 μm. The volcanic particles remain airborne for about two years, but smoke from nuclear fires would last a decade.The climatic response to the smoke was surprising. Sunlight was immediately reduced, cooling the planet to temperatures lower than any experienced for the past 1,000 years. The global average cooling, of about 1.25 degrees Celsius (2.3 degrees Fahrenheit), lasted for several years, and even after 10 years the temperature was still 0.5 degree C colder than normal. The models also showed a 10 percent reduction in precipitation worldwide. Precipitation, river flow and soil moisture all decreased because blocking sunlight reduces evaporation and weakens the hydrologic cycle. Drought was largely concentrated in the lower latitudes, however, because global cooling would retard the Hadley air circulation pattern in the tropics, which produces a large fraction of global precipitation. In critical areas such as the Asian monsoon regions, rainfall dropped by as much as 40 percent. The cooling might not seem like much, but even a small dip can cause severe consequences. Cooling and diminished sunlight would, for example, shorten growing seasons in the midlatitudes. More insight into the effects of cooling came from analyses of the aftermaths of massive volcanic eruptions. Every once in a while such eruptions produce temporary cooling for a year or two. 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In our scenario, daylight would filter through the high smoky haze, but on the ground every day would seem to be fully overcast. Agronomists and farmers could not develop the necessary seeds or adjust agricultural practices for the radically different conditions unless they knew ahead of time what to expect. In addition to the cooling, drying and darkness, extensive ozone depletion would result as the smoke heated the stratosphere; reactions that create and destroy ozone are temperature-dependent. Michael J. Mills of the University of Colorado at Boulder ran a completely separate climate model from Robock's but found similar results for smoke lofting and stratospheric temperature changes. He concluded that although surface temperatures would cool by a small amount, the stratosphere would be heated by more than 50 degrees C, because the black smoke particles absorb sunlight. This heating, in turn, would modify winds in the stratosphere, which would carry ozone-destroying nitrogen oxides into its upper reaches. Together the high temperatures and nitrogen oxides would reduce ozone to the same dangerous levels we now experience below the ozone hole above Antarctica every spring. Ultraviolet radiation on the ground would increase significantly because of the diminished ozone. Less sunlight and precipitation, cold spells, shorter growing seasons and more ultraviolet radiation would all reduce or eliminate agricultural production. Notably, cooling and ozone loss would be most profound in middle and high latitudes in both hemispheres, whereas precipitation declines would be greatest in the tropics. The specific damage inflicted by each of these environmental changes would depend on particular crops, soils, agricultural practices and regional weather patterns, and no researchers have completed detailed analyses of such agricultural responses. Even in normal times, however, feeding the growing human population depends on transferring food across the globe to make up for regional farming deficiencies caused by drought and seasonal weather changes. The total amount of grain stored on the planet today would feed the earth's population for only about two months [see “Could Food Shortages Bring Down Civilization?” by Lester R. Brown; SCIENTIFIC AMERICAN, May]. Most cities and countries have stockpiled food supplies for just a very short period, and food shortages (as well as rising prices) have increased in recent years. A nuclear war could trigger declines in yield nearly everywhere at once, and a worldwide panic could bring the global agricultural trading system to a halt, with severe shortages in many places. Around one billion people worldwide who now live on marginal food supplies would be directly threatened with starvation by a nuclear war between India and Pakistan or between other regional nuclear powers.

#### Nuclear war decimates crop yield- empirics prove

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In the event of nuclear war, targets in cities and industrial areas would emit light-absorbing particles (i.e., black carbon, soot, or elemental carbon) into the atmosphere from fires. By blocking sunlight, elemental carbon would cause significant changes to solar radiation, temperature, and precipitation patterns. For example, evidence suggests “volcanic winters” and “years without summers” follow large volcanic eruptions such as Tambora in 1815. Under these conditions, unusual mid- to late-summer cooling and frost have caused crop failure over millions of hectares of cultivated areas (Post 1977; Stommel and Stommel 1979; Harington 1992; Oppenheimer 2003). Less known, however, is whether similar crop failure might be caused by a regional nuclear conflict. Vulnerability of agricultural systems to nuclear war was recognized in the 1980s. Ehrlich et al. (1983) reported subfreezing temperatures, low light levels and high doses of UV light as drivers of large-scale decline in crop productivity in the Northern Hemisphere following a large-scale nuclear war. Harwell and Cropper (1985), investigated the agricultural effects of a large-scale nuclear war using both an empirical approach and simple crop growth models and concluded that significant reduction in crop yields and associated production could occur, primarily caused by shortening of the growing season and reduction of thermal time needed by crops to reach physiological maturity. Sinclair (1986) simulated potential soybean production following a nuclear winter in Midwestern U.S. and showed that temperature reductions of 2–4 °C throughout the growing season could substantially reduce yields.

#### Nuclear war hurts yield of corn and soybeans- economic collapse

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Our results suggest that temperature and solar radiation perturbations in midlatitude locations play a greater role than precipitation in reducing yields. Based on observational evidence, recent work by Kucharik (2006, 2008) has shown that increases in the growing season length and the timing of sowing and harvest dates due to increases in temperatures and changes in agricultural technology (e.g., improved hybrids) have contributed to increased corn and soybean yields. In our study, cooler conditions associated with a nuclear conflict, which may shorten the frost-free growing season, could lead to fewer calendar days for crops to intercept radiation and perform photosynthesis. In contrast, should temperatures increase with nuclear conflict generated short-term climate change during the growing season, an accelerated rate of growing degree day accumulation could contribute to crops progressing through their phenological stages more quickly, with fewer calendar days to accumulate biomass. Thus, temperature changes can create a myriad of feedbacks affecting yield; some could be positive, and some negative, but the time of year these temperature anomalies occur is critical. Our results indicate that average lower temperatures in spring associated with the nuclear conflict could delay planting, but depending on the course of temperature accumulation during the rest of the season, crops could achieve physiological maturity at an earlier or later date. While later planting could be an adaptation option to limit this temperature effect, one needs to consider the increased risk of encountering killing temperatures before physiological maturity occurs (Sacks and Kucharik 2011). Our analysis emphasizes the impact of cooler spring conditions on delayed planting, a shorter growing period and lower yields. The potential for adapting maize-soybean systems to climate change is well documented (e.g., Lobell et al. 2008; Ainsworth and Ort 2010). These strategies may include development of new technologies that permit crops to be more drought- and cold-resistant or have different carbon allocation strategies (Lopes et al. 2011). For example, the trend toward earlier corn planting in the U.S. (e.g., Kucharik 2006) is partially supported by development of temperature-activated polymers applied to seeds. Moreover, planting densities have increased, and harvest index has also increased through the development of stay-green hybrids (Tollenaar and Lee 2010). Where water is limited, irrigation may be a solution. The Midwest is not generally considered a water-limited region so a small investment in irrigation infrastructure could alleviate the reduced precipitation expected as a result of a regional nuclear war. While GCM output suggests that the largest precipitation, temperature, and radiation changes occur in years 2–5, the yield response to these anomalies is greatest in year five for all sites and crops. However, given that the GCM results used in this study reflect only one scenario and one climate model, the effects could be coincidental, as a regional conflict could bring about considerable variability in worldwide climate conditions. Thus the results presented here are indicative of the amplitude of effects that could result in the Midwest or elsewhere. Yet the Robock et al. (2007) study involved three runs whose mean is used here, so variability may already be reduced: it is possible that for any individual realization there might be greater extremes. Several reasons can explain the differences between observed and Agro-IBIS predicted yields. First, we used a 10 year (1995–2006) average of USDA yield data. However, summer crop yields are generally increasing at a rate of about 1.3 % per year (NASS). Agro-IBIS is calibrated to simulate current (e.g., 2012) yields, so it is somewhat expected that yields are higher than the longer-term observed averages. Since the USDA yields are representative of ~2000 (mid point of 1995–2006), there are 12 years between that value of yield and the most current value simulated by Agro-IBIS (ca. 2011). With an average increase in yields of 1.3 % per year, the current yields would be about 14 % higher than the values on the graph for observed and that would close the gap between observed and simulated. The issue of declining model performance for corn as one goes from counties in IA, IL, IN to MO is partially explained by the fact that counties with higher number of harvested acres in the USDA data generally lead to a better comparison with Agro-IBIS (especially for corn) because averaging occurs over many more combinations of weather, soils, and management combinations (Kucharik 2003). In fact the MO site has the least area of planted acres of both crops of all sites. Therefore, this is not necessarily a model issue, but rather a quality of data issue when comparing results from a point simulation (or collection of points) to county averages. It is possible to tune various parameters in Agro-IBIS to match observed yields perfectly but this may inadvertently lead to a model “over fitting”. However, there is no guarantee that the model will agree better across all sites because fundamental issues that likely contribute to variation in yields from year to year as well as across sites will not be accounted for. So the parameter adjustment approach would not necessarily be simulating yield average values from about 10–15 years ago, especially considering that the current work is not about model fitting and calibration for the past, but about looking at potential yield responses for some point in time. Our research suggests that both maize and soybeans may experience notable yield reductions in the event of a nuclear conflict beyond the natural variation of both crops. The United States is the world’s largest producer and exporter of corn; the Midwest supplies 80 % of this production. If yield declines as suggested here were to occur, overall production could be depressed for several years following the nuclear conflict, affecting both market conditions and livelihoods. While the economic impacts are not explored here, they are likely to be large, given the prominence of the contribution of corn and soybeans to domestic market needs for food, feed, and fuel as well as to agricultural exports. Unlike global climate change caused by radiative forcing, the changes created by a nuclear conflict would have different duration: the radiative forcing from greenhouse gases are expected to persist for a century or more while that generated by a nuclear conflict is likely to last for only a decade (Toon et al. 2008). Nevertheless, the economic and societal consequences of yield changes resulting from this short-lived climatic alteration could eclipse the long-term changes from greenhouse gas emissions that allow ample time for development and application of a variety of adaptation strategies to mitigate yield losses. Therefore we conclude that the best way to limit the effects of a nuclear war on agriculture is to eliminate all nuclear weapons.

#### Nuclear weapons hurts crop yields

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The Natural Resources Defense Council (NRDC 2002) has suggested that both India and Pakistan have nuclear weapons and have been threatening each other over the Kashmir Region and other issues. Investigations by Robock and Toon (2010) have demonstrated that even a limited nuclear battle involving the nuclear arsenals of India and Pakistan would have significant climatic impacts throughout the world. They estimated that mean global temperatures would decline an average of 1.25 C with greater declines occurring in the interior regions of North America and Eurasia (Robock and Toon 2010). In addition, significant declines in precipitation were projected globally. Estimates are that these climatic changes could cause significant declines in global food production and could trigger increased famines on top of the current world malnutrition problem—currently [66 % of the world population is malnourished (WHO 2000; FAO 2009). Of the[4700 million malnourished humans, 2000 million are iron malnourished (WHO 2000) and 1020 million are protein/calorie malnourished (FAO 2009). Specifically in India, 48 % children under the age of 5 are reported to be chronically malnourished (Arnold et al. 2009). Globally, grains make up [80 % of the world food supply (Pimentel and Pimentel 2008). Although much of the world croplands are occupied by grains and other crops, malnutrition is still a growing problem globally (WHO 2000; FAO 2009). Furthermore [99.7 % of human food comes from soils of the terrestrial environment, while\0.3 % comes from the oceans and other aquatic ecosystems (FAOSTAT 2011). Worldwide, of the total of 13 000 million hectares of land area on earth the percentages according to use are: cropland 11 %, pasture land 27 %, forest land 32 %, urban development 9 %, and other 21 %. Most of the remaining ‘‘other’’ land area (21 %) is unsuitable for crops, pastures, and/or forests because the soil is too infertile or shallow to support plant growth or the climate and region are too harsh, cold, dry, steep, stony, or wet (FAOSTAT 2011). Most of the suitable cropland is already in use growing crops. In 1960, when the world population numbered only 3000 million, \*0.5 ha was available per person for the production of a diverse, nutritious diet of plant and animal products (Giampietro and Pimentel 1994). It is widely agreed that 0.5 ha of cropland is essential for a healthy diet. As the human population has continued to increase, an expansion of diverse human activities has dramatically reduced cropland and pasture land. Much vital cropland and pasture land has been covered by transportation systems and urbanization. In the US, about 0.4 ha (1 acre) of land per person is covered with urban developments and highways (USBC 2009). In 1950, only 20 % of the world population was malnourished (Grigg 1993). However, today the percentage of people that are malnourished is [66 % (WHO 2000; FAO 2009). Thus, the impact of a Royal Swedish Academy of Sciences 2012 www.kva.se/en 123 AMBIO DOI 10.1007/s13280-012-0295-0 limited nuclear war simulated in this study has great significance. US CORN BELT The US Corn Belt is the most important food producing area in the United States, accounting for about 70 % of US grain (Iowa, Illinois, Nebraska, Minnesota, Indiana, and Wisconsin) (USDA 2010a). This area is ideal for grain production because of the productive soils (available nutrients), favorable temperatures and rainfall (Troeh et al. 2004; Average Weather in Des Moines 2011). The soils are rich with organic matter (4–5 %), essential for high crop productivity. The growing season temperatures are also ideal for crop production. Especially vital is seasonally well-distributed rainfall that ranges from about 80 to 89 cm of precipitation as rainfall per year (Average Weather in Des Moines 2011; Neild and Newman 2011). The two dominant crops in the Corn Belt are corn and soybeans along with some wheat. Corn and soybeans are frequently grown in rotation with one another. This rotation facilitates both the insect and the disease control. In addition, when corn is grown after soybeans, the corn crop benefits from about 40 kg/ha of nitrogen remaining after the soybean crop is harvested (O’Leary et al. 2008). CLIMATIC DATA FOR THE CORN BELT REGION DURING THE SIMULATED NUCLEAR WINTER STUDY Alan Robock, Rutgers University developed two models to project the effects on world climate as a consequence of a limited nuclear war between India and Pakistan (pers. comm.). The Corn Belt region was selected because[70 % of US grains are produced in this region of the United States (USDA 2010a). The changes modeled in the Corn Belt were developed by Robock and his staff for an area centered on 42N, 95W in the United States, about 2.6 km WSW of Halbur and Carroll, Iowa (Degree Confluence Project 2012). The simulated climatic data for this investigation (Table 1) were provided by Robock. Before reporting more on how we made these climate impact assessments, we should report that Texas and the Southwestern region of the US has had little or no rain for the past year which makes planting any corn, soybeans, or winter wheat impossible. In addition, the Corn Belt is presently (May 2011) flooded and the farmers in this region will be unable to plant as usual in early May and will be lucky to plant by early June. Thus, yields of corn, soybeans, and winter wheat will be severely reduced (50 % or more). This provides a little background of how difficult it is to estimate the impacts of the limited nuclear war on the production of corn, soybeans, and winter wheat as suggested by the simulated temperature, precipitation, sunlight, and frost impacts. After examining all the information on temperature impacts on corn and soybeans (Iowa State University Extension 2001; Nielsen and Christmas 2002; Lobell and Asner 2003; Elmore et al. 2006; Food Inc. 2008; Kucharik and Serbin 2008; Schlenker and Roberts 2009; USDA 2010a; Climatetemp.info/usa/des-moines-iowa.html 2011), we finally settled on 0.07 impact times each C temperature decline that corn and soybeans were exposed to. For example, a 2 C decline in temperature resulted in a 14 % decline in corn or soybean yield. Schlenker and Roberts (2009) used the aforementioned approach for each temperature increase related to global temperature change. After examining all the literature, we concluded that this was the best approach to be used in the assessment for each 1 C decline. Winter wheat—because of when it is planted, grows, and is harvested—did not appear to be affected by cool temperatures (USDA 2010a). The impacts of reduced rainfall were the most difficult to deal with because of the variability in impacts on corn, soybeans, and winter wheat (see Tables 2, 3, 4). We finally decided that the best approach would to calculate the mean rainfall for the particular growing season for corn and soybeans and for winter wheat using rainfall data for Des Moines, Iowa and assumed that this would result in an expected yield of about 9000 kg/ha for corn and 3000 kg/ ha for winter wheat and soybeans. Then, we examined the simulated rainfall data reported for the growing season and what the experimental impacts were for the crops in the Corn Belt. Then the yields of corn, soybeans, or winter wheat were reduced an equivalent percentage based on the percentage reduction in rainfall reported in the simulation. These crop yield data reductions based on rainfall reductions for the simulations for the three crops did not appear to be unreasonable based on the data for corn, soybeans, and winter wheat yields (Satorre and Slafer 1999; Changnon and Hollinger 2003; Lobell and Asner 2003; Wilhite 2006; Andersen 2007; Integrated Pest Management Resources 2008; Environmental Working Group 2009; Swoboda 2010; Climatetemp.info/usa/des-moinesiowa. html 2011). CROP YIELD DATA FOR THE SIMULATED NUCLEAR CONFLICT STUDY For the model year ZERO corn yields are assumed to average 9000 kg/ha (USDA 2010a) (Table 2). The model year ONE corn yield is 90.5 % of year ZERO or 8145 kg/ha. The most severe temperature and moisture reductions were projected to occur during year TWO. Thus, the total corn yield for year TWO was calculated to be reduced significantly by 72.5 % or to an average mean yield of 2470 kg/ha (Table 2). Variations in frost and solar radiation were not assumed to have an impact on corn yields for this experimental period. Soybeans would suffer more severe impacts on yields from global climatic effects than corn Based on the reduced mean temperature and rainfall for model year ONE, it is calculated that soybean yield might be reduced a total of 1410 kg/ha (47%) from temperature reduction (Table 3) to a mean average yield of 1695 kg/ha. For model year TWO, based on the reduced temperature and rainfall estimates the total soybean yield is calculated to be reduced by 100 %—a total loss. Variations in frost and solar radiation were not assumed to have an impact on soybean yields for any of the growing seasons during the experimental period. Winter wheat would also suffer significant impacts from global climatic effects due to the climatic impacts of global climate change due to simulated nuclear war (Table 4) but less than either corn or soybeans. For the model year ZERO winter wheat yields were assumed to average 3000 kg/ha (USDA 2010a). Based on the reduced mean temperature and respective model years and the range of climatic conditions conducive to wheat, winter wheat yield would not be affected by temperature reductions predicted. Reduced rainfall is calculated to reduce winter wheat yields 120 kg/ha (4 %) for year ONE (Table 4). Reduced rainfall during model year TWO would be expected to reduce winter wheat yields 420 kg/ha (14 %) (Table 4). Thus, the reduction in winter wheat yield for model year TWO is significant. Variations in frost and solar radiation are not assumed to have an impact on winter wheat yields for this experimental period. DISCUSSION: IMPACTS ON OF A LIMITED NUCLEAR WAR ON THE US FOOD SYSTEM Total US corn grains produced are estimated to be about 355 million metric tons per year, plus about 90 million metric tons of soybeans produced per year (USDA 2010a). US grains are consumed directly as bread, cereals, drinks, and other products, and about 150 million tons of the grains are fed to livestock to produce milk, eggs, and meat (World Resources Institute 2007). Thus, reducing grain production in the Corn Belt by[65 % would have a major impact on the US food system and diet of individual Americans. In addition, the US exports about 55 million metric tons grain per year and any production decline will draw down the supply of grain for consumption or export (USDA 2010a). One approach to conserve our grain might be for the US to reduce exports of grain (USDA 2010a). Such a change could increase the malnutrition problem (Pimentel and Satkiewicz 2012). An additional 105 million tons or 30 % of corn grain is converted into ethanol (Pimentel and Patzek 2008; Weise 2011). This provides 45 000 million liters of ethanol but 1.5 l of liquid fossil fuel are required to produce each liter of ethanol (Pimentel et al. 2012). Thus, there is a net loss of 70 000 million liters of liquid fossil fuel and the nation is importing oil and natural gas to produce the ethanol (Pimentel 2012). Subsidies (paid by US taxpayers) of[$12 000 million per year are the only reason that the US is producing corn ethanol (Koplow and Steenblik 2008). Simply discontinuing the federal government subsidies would likely cause most of the corn ethanol production to cease and free up corn grain for other uses. Note the many uses of corn leaves only 45 million metric tons available for human consumption in the United States (USDA 2010b) which is the reason that corn grain and food prices have increased by 20 % since 2005; food costs have increased about $9000 million annually (US Congressional Budget Office 2007). Limited Nuclear War and Potential Famine In calculating the potential climate impacts of a limited nuclear war on corn grain production, wheat production and soybean production in the US Corn Belt, the greatest climatic impact was estimated to be during year TWO because it would take some time for the climate impacts to reach the United States Corn Belt. The production of corn, wheat, and soybeans are projected to suffer approximately a 65 % reduction in crop yields during the year TWO of the modeled nuclear war (see the year ONE impacts on corn grain, soybeans, and winter wheat). Thus, instead of 445 million metric tons of grain (including soybeans) for the US grain sector, only 242.5 metric million tons of grains are potentially available. This quantity of grain (including soybeans) is totally inadequate for the population of 310 million people in the US. Some potential changes could be made in the food system to lessen this impact. These changes might include reducing livestock products like meat, milk, and eggs by one half which could be achieved by moving to a grass-fed livestock system in the US, and producing only animal products like milk and beef from livestock that can subsist on grass (Pimentel et al. 1980). This would free up about 150 million metric tons of grain, including soybeans. Also, assume that the export of 55 million metric tons of grain would totally cease. The result would be about 392.5 million metric tons of grain (including soybeans) available for the American people as food. This shift, a response to reduced grain production due to a limited nuclear war, away from grain exports would create severe grain shortages worldwide and increase world malnutrition (USBC 2009; USDA 2010a). SUMMARY OF NUCLEAR WAR IMPACTS ON FOOD SUPPLY IN THE US The potential impacts of climate changes in the United States from a limited nuclear war between India and Pakistan and the impacts on agriculture and food supply in the US have been assessed. Based on the simulated climatic data for the US Corn Belt in Table 1, specifically changes in temperature and rainfall, the sharpest decline in yield for all three crops considered is for model year TWO with a 72.5 % yield decline for corn, a 100 % yield decline for soybeans, and a 7 % decline for winter wheat. For year THREE the corn yield recovers to 7457 kg/ha, 83 % of the year ZERO yield while soybean recovers to 2392 kg/ha, 80 % of the year ZERO yield and winter wheat recovers to 2920 kg/ha, 97 % of the year ZERO yield. Facing production declines in soybeans and corn predicted in year TWO after the modeled limited nuclear war would likely force the US to end grain exports to make up some of the grain deficit. If no grain from the Corn Belt is exported and if livestock production is changed to a grassfed system and corn ethanol production is eliminated by discontinuing government subsidies, there would be minimally sufficient grain and soybeans for the American people. Of course, if US grains exports ceased, this might increase malnourishment in Japan, Mexico, Egypt, Yemen, Nigeria, China and some Asian countries (USBC 2009).

#### Environmental effects of nuclear weapons- agriculture, forests, water, climate

(Abeer Majeed, “The Impact of Militarism on the Environment”, Research report for Physicians for Global Survival, 2/04, http://weaponspollute.org/wp-content/uploads/2010/12/militarism\_environment\_web.pdf)

 Agriculture— Although radiation occurs naturally in soil, excessive contamination of agricultural lands results in human exposure through ingestion of food. Radiation bioaccumulates and the most dangerous isotopes are those readily taken up by plants and passed on to animal products like milk and meat. Factors that further intensify exposure include: soil type, method of tilling crops, climate, season, and biological half-lives that determines amount taken up by plants or leached into the ground.

## Disease-War

#### Disease causes ethnocentric and xenophobic cultures, causing war

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Geographic and cross-national variation in the frequency of intrastate armed conflict and civil war is a subject of great interest. Previous theory on this variation has focused on the influence on human behaviour of climate, resource competition, national wealth, and cultural characteristics. We present the parasite-stress model of intrastate conflict, which unites previous work on the correlates of intrastate conflict by linking frequency of the outbreak of such conflict, including civil war, to the intensity of infectious disease across countries of the world. High intensity of infectious disease leads to the emergence of xenophobic and ethnocentric cultural norms. These cultures suffer greater poverty and deprivation due to the morbidity and mortality caused by disease, and as a result of decreased investment in public health and welfare. Resource competition among xenophobic and ethnocentric groups within a nation leads to increased frequency of civil war. We present support for the parasite-stress model with regression analyses. We find support for a direct effect of infectious disease on intrastate armed conflict, and support for an indirect effect of infectious disease on the incidence of civil war via its negative effect on national wealth. We consider the entanglements of feedback of conflict into further reduced wealth and increased incidence of disease, and discuss implications for international warfare and global patterns of wealth and imperialism.

#### War

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The recently revealed association between cross-national variation in the unidimension collectivism-individualism and the severity of infectious diseases ([Fincher et al., 2008](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b24)) suggests a model with the potential to integrate the diversity of published ideas and findings with respect to the incidence of civil war. Collectivism-individualism is a cultural dimension that describes people's tendency to place individual goals above those of society or the group as a whole (individualism), or to see oneself as an integral part of a group whose goals supersede that of the individual (collectivism) ([Hofstede, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b35)). Individualist societies are characterized by individuals who look after themselves and their immediate, nuclear families, have many, but less intimate, interactions with a greater diversity of social partners, and who make few distinctions between in-group and out-groups; whereas collectivist societies are characterized by ethnocentric and xenophobic values, and therefore by individuals integrated into strong, cohesive in-groups, more extended family nepotism, fewer but more intimate social relations, stronger distinctions between in-group and out-groups (see review in [Gelfand et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b28)), and decreased willingness to engage in social contact with out-group members ([Sagiv & Schwartz, 1995](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b50)). [Ember & Ember's (1992b)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b17) finding that socialization for mistrust independently predicts warfare suggests that the heightened ethnocentrism and xenophobia of collectivist societies may be salient; their source for this variable ([Barry et al., 1976](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b7)) describes it as mistrust for members of the community who are outside the family. While collectivists, compared to individualists, socialize more intimately with members of their in-group, particularly members of extended families, they draw sharper distinctions between their in-group and out-groups ([Gelfand et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b28)). Further, [Barry et al. (1976)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b7) indicates that “sorcery and witchcraft generally indicate a low rating of trust.” (p. 95) The positive association between collectivism and in-group religious beliefs ([Gelfand et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b28); [Hofstede, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b35)) further suggests that the findings of [Ember & Ember (1992b)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b17) may be explained by cross-cultural differences in collectivism-individualism. In a cross-national analysis, [Fincher et al. (2008)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b24) demonstrated that individualism correlates negatively (and collectivism correlates positively) with the intensity of human infectious disease in the environment. Previous studies have documented an association between ethnocentrism ([Navarrete & Fessler, 2006](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b44)) and xenophobia ([Faulkner et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b19)) and perceived vulnerability to disease. This association suggests that the focus of social contact on in-group members, and avoidance of contact with out-group members, may be an important mechanism for management and avoidance of the risk of infection. [Fincher et al. (2008)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b24) put forward and support the theory that collectivism is a cultural manifestation of this evolved anti-pathogen psychology. There is significant geographic variation in human pathogens; they are especially diverse and severe in low latitudes ([Guernier, Hochberg & Guegan, 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b32); [Low, 1990](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b38)). Human populations become locally adapted to local pathogens through the process of parasite-host coevolution ([Ewald, 1994](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b18); [May & Anderson, 1983](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b42); see [Fincher & Thornhill, 2008a](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b22), for evidence of localized immune defences among human groups). This local coadaptation between humans and their pathogens makes inter-group contact costly, by increasing the risk of contracting a pathogen to which an individual is not adapted. The intense in-group social interaction characteristic of ethnocentric societies also serves as an important buffer against the morbidity and mortality of infectious disease ([Sugiyama, 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b55)); in-group social support may be critical in surviving periods of debility due to disease. As a result, in conditions of high infectious disease prevalence, selection favours people who adaptively express the evolved, conditional psychology that promotes avoidance of out-group members, and who concentrate their social interactions more intensely on the local in-group: those in the extended family and others with similar immunological defences. Because the intensity of infectious disease is greatest at low latitudes, localization of immunological defence is greatest at low latitudes as well, as are the xenophobic and ethnocentric attitudes these evoke. [Fincher & Thornhill (2008a,b](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b22)) further propose that the ethnocentric and xenophobic values of cultures in areas of high pathogen stress generate cultural diversity. As the process of localized parasite-host coevolution proceeds within a cultural group, spatial variation emerges both in the immune systems of the group members, and in the pathogens they carry. This spatial variation leads to mismatch between the immune systems of members of a local group and the pathogens carried by outsiders. This process leads to the emergence of new social boundaries based on language, norms, and values, as people assort themselves in order to avoid infection by novel pathogens to which their immune systems are not adapted. As a result, groups fission and diverge culturally, producing novel cultural diversity ([Fincher & Thornhill, 2008a,b](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b22)). It is likely that this fissioning process is not always a peaceful one, as the xenophobia that discourages out-group contact and novel contagion exposure makes it less likely that conflict between fissioning groups over previously shared territories and resources will be resolved in a cooperative manner. We hypothesize that the process of group fissioning may often take the form of intrastate armed conflict or civil war. Similarly, the xenophobia of collectivist groups leads to hostility between neighbouring groups within a region; this contributes to the occurrence of intrastate conflict where political boundaries encompass groups that regard themselves as distinct from their neighbours (e.g. the Hutus and Tutsis of Rwanda). [Schaller & Neuberg (2008)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b51) discussed the relationship of evolved intergroup prejudices to intergroup conflict, and hypothesized that the xenophobic attitudes evoked by the risk of disease may contribute to intergroup aggression. This hypothesis is further suggested by [Hofstede's (2001)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b35) characterization of “high risk of domestic intergroup conflict” in collectivist societies (in regions with high intensity of infectious disease; [Fincher et al., 2008](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b24)) as a key difference from individualist societies ([Hofstede, 2001, p. 251](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b35)). This hypothesis predicts that more frequent intrastate armed conflict and civil war will be associated with increasing intensity of infectious disease. In addition to the contribution to inter-group hostility by the ethnocentrism and xenophobia of cultures in regions of high intensity of infectious disease, disease has been shown to have a negative effect on national wealth. This can happen through two pathways. First, infectious disease can incapacitate workers on a large scale; this depresses economic growth and accounts for a significant amount of variation in wealth ([Gallup & Sachs, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b26); [Price-Smith, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b48)). Second, infectious disease may have an indirect, negative effect on wealth through its evocation of ethnocentric and xenophobic cultures. The negative association between collectivism and wealth across countries is well recognized (e.g. [Hofstede, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b35)). There has been debate as to the direction of causality of this association (review in [Gelfand et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b28)), but [Thornhill, Fincher & Aran (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b58) argue that it is individualism that leads to increased wealth (and therefore collectivism, and associated xenophobia and ethnocentrism, lead to relative poverty), as individualist cultures have higher democratization, and thus people are more willing to invest in public welfare, health, infrastructure, and other public goods; whereas in collectivist societies, people are unwilling to invest in public goods that will be shared beyond their extended family or ethnic group. This differential investment in public welfare maintains widespread poverty in collectivist societies while individualist societies show relative prosperity. Given the well-established negative correlation between national wealth, as measured by GDP per capita, and civil war (e.g. [Ember & Ember, 1992b](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b17); [Fearon & Laitin, 2003](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b20)) we predict that infectious disease will make a further, indirect, positive contribution to the frequency of intrastate armed conflict and civil war, through its influence on decreasing national wealth. [Price-Smith (2001)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b48) investigated the association between re-emerging infectious disease and various measures of state capacity, including GDP per capita, and argued for the important influence of infectious disease on intra- and inter-state warfare. However, he used infant mortality rates and life expectancy as proxies for pathogen severity, and did not investigate the association between pathogen severity and conflict per se. Here, we will examine this relationship specifically. The causal pathway we suggest is one that begins with climate's influence on the intensity of infectious disease. Geographic variation in temperature and rainfall causes geographic variation in the intensity of human parasites ([Guernier et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b32)). In this model, infectious disease causes the emergence of societies with ethnocentric and xenophobic cultural values in areas of high parasite stress, such as in low latitudes, and relatively xenophilic societies in areas of low intensity of infectious disease. This produces geographic and regional variation in the wealth of nations, and leads to differences in the frequencies of intrastate, inter-group conflict as groups within these nations compete for resources. Thus, this model unifies a number of the diverse variables known to correlate with the frequency of warfare, and completes the causal pathway from climate and infectious disease to the occurrence of intrastate conflict. In order to test this model, we conducted a series of regression analyses of the cross-national incidence of intrastate armed conflict and civil war and its causes, which we present below.

#### More war

(Kenneth Letendre, Department of Biology and Department of Computer Science at the University of New Mexico, Corey L. Fincher, Department of Biology at the University of New Mexico, Randy Thornhill, Department of Biology at the University of New Mexico “Does infectious disease cause global variation in the frequency of intrastate armed conflict and civil war?”, Biological Reviews, 4/1/10, http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full)

These results support the direction of causality we propose here—that it is variation in intensity of infectious disease that causes variation in the frequency of intrastate armed conflict and civil war, rather than the converse. In our analysis of these conflicts by country-year, control variables such as GDP per capita, population size, etc., were entered as yearly series and lagged by one year, while pathogen severity was entered as a time-invariant, country-specific effect. This method is standard in analysis of conflict onsets ([Hegre & Sambanis, 2006](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b34)) and ensures that, for example, a correlation between GDP per capita and onset of civil war does not reflect the endogenous effect of a civil war causing a reduction in GDP per capita.

Of course civil war can cause outbreaks of disease, for example among refugee populations. This results from the displacement of people by warfare, political instability, and accompanying reduction in economic growth, leading to the collapse of public health infrastructure ([Ghobarah et al., 2003](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b29)). Thus our statistical models control for factors that mediate the causal influence of civil war on subsequent disease outbreaks; the remaining significant effects of infectious disease on the occurrence of civil war therefore represent the causal pathway in which infectious disease stress causes conflict and civil war via the evocation of xenophobic and ethnocentric values.

So is it intensity of infectious disease that drives human behaviour, or vice versa? Certainly human behaviour with respect to social organization and mating can influence the prevalence and evolved virulence of infectious diseases, and particularly sexually transmitted diseases ([Altizer et al., 2003](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b3); [Ewald, 1994](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b18)). Nevertheless it is variation in climate, independent of factors such as human demography and wealth, that drives persistent, large-scale, geographic and cross-national variation in the distribution of human infectious diseases ([Guernier et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b32)). It is this variation that is reflected in the pathogen prevalence variable used in the analysis presented here. Although the Contemporary Pathogen Severity Index used here is one composed of contemporary measures of the severity of infectious disease ([Fincher et al., 2008](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b24)), its high correlation with Low's (1989, 1990) historical pathogen severity index, as applied to nations by[Gangestad & Buss (1993)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b27), confirms that cross-national variation in these measures is relatively consistent over time. This supports our causal model, and also validates the use of contemporary measures of infectious disease in examining the historical causation of patterns in human societies and behaviours.

R. Thornhill, C.L. Fincher & K. Letendre (in preparation) completed a path analysis of the Economist Intelligence Unit's Global Peace Index for 2008 (<http://www.visionofhumanity.org/gpi/results/rankings.php>) which supports the causal model proposed here. Intrastate armed conflict and civil wars produce a zero-inflated variable when collapsed into counts for each country, and are therefore problematic for purposes of path analysis. The Global Peace Index is an index of overall conflict composed of 24 indicators including level of distrust in other citizens, political instability, numbers of external and internal conflicts, homicide rate, etc. The analysis by R. Thornhill, C.L. Fincher & K. Letendre (in preparation) supported a causal model in which infectious disease causes the emergence of collectivist culture; infectious disease and collectivist culture together cause low GDP per capita; and degree of peace is caused negatively by collectivism, positively by GDP per capita, with an additional direct, positive causal path directly from infectious disease. Thus the causal pathway we argue for here—with infectious disease causing the emergence of collectivist cultures, and thereby leading to increased frequency of civil war—is supported theoretically and empirically.

(3) Infectious disease and conflict

We find that infectious disease has a significant, direct influence on the onset of conflicts with at least 25 battle deaths, but which never result in more than 1000 deaths in a year. Conflicts such as these bear more resemblance to the kinds of conflicts humans have engaged in for millions of years, than do large-scale conflicts that claim thousands of lives. It may be that the ethnocentrism and xenophobia that infectious disease engender are more likely to result in small-scale conflict among families and clans independent of wealth; whereas large-scale conflict involving many sub-groups more often results from broader economic grievance, opportunity for rebellion ([Collier & Hoeffler, 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b11)), or a state's inability to suppress violent conflict ([Fearon & Laitin, 2003](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b20)). Despite this, we argue that intrastate armed conflict and civil war are not strictly modern phenomena. The species-typical psychology and behaviour that forms the link between parasites and violent intergroup conflict is implicated in patterns of warfare through history and in societies of all scales.

Violent conflict involves a degree of contact that increases the risk of disease transmission above that of complete isolation, particularly in conflicts in primitive societies where warfare often takes the form of hand-to-hand combat (but see [Okada & Bingham, 2008](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b47), for a discussion of the importance of the advent of thrown weapons in human conflict and cooperation). If the theoretical link between infectious disease and violent intergroup conflict is the need for groups to isolate themselves from other groups that may be carrying novel pathogens, why does this result in violent conflict? Because we require the same resources to survive and reproduce, in humans, as in any other species, our most intense competitors are other conspecifics. [Alexander (1979)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b1) argued that humans, especially, had become their own greatest source of mortality, and hence their own greatest source of selection, because of their elimination of the threat of predators and competitors for food sources. Unlike asocial species whose interactions are purely competitive except for mating purposes, humans also have the potential for cooperative social interaction with members of our own species. Often the benefits of cooperative social interaction dominate over the costs of our competitive interactions, and our relations are amicable and cooperative on the whole. The risk and cost of contracting novel pathogens from those outside our group increase in regions where infectious disease is intense, and this imposes a cost on intergroup cooperative interaction. As a result, people cease to regard out-group members as potential social partners, and the competitive aspects of our intraspecific interactions become dominant. Although there is a cost to engaging in violent intergroup conflict, in terms of risk of exposure to the very disease xenophobia is designed to avoid, the brief risk of exposure during this conflict is less than the protracted risk should two groups interact socially over an extended period or share a resource such as a water source or living space. As a result, when two groups living in a region with a high intensity of infectious disease both need access to a common resource, the conflict is more likely to be solved by the use of intergroup violence than in regions where the cost of infectious disease is less. [Alexander (1979, 1989](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b1)) included escape from the selection pressure of disease in his description of humans' ecological dominance. However we argue that infectious disease has remained an important challenge that humans must address, even to the modern day. (Also see [Thornhill et al., 2009](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b58).)

(4) Disease, resources, and competition

The argument that infectious disease ultimately causes geographic and cross-national variation in the frequency of intrastate armed conflict does not diminish resource competition as a cause of this conflict. Ultimately, all conflict occurs as a result of competition for resources; thus in our model the robust negative relationship between resource availability and the frequency of intrastate armed conflict ([Hegre & Sambanis, 2006](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b34)) represents a real causal relationship. To this causal framework, our model adds variation in the intensity of infectious disease, and the value systems evoked under these conditions ([Fincher et al., 2008](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b24)), which cause relative impoverishment ([Price-Smith, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b48)) and increasing likelihood that intergroup conflicts over resources will be resolved through warfare rather than through cooperative means.

[Collier (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b9) explores the characteristics of impoverished modern nations, and the “traps” that prevent the poorest nations from realizing the development and economic growth enjoyed by wealthy nations. These are: the conflict trap, in which conflict causes setbacks to economic progress, which in turn cause more conflict; the natural resource trap, in which countries whose primary natural resources are distributed such that they can be controlled by a few, and the gains from which are therefore not invested in development and long-term growth; landlocked with bad neighbors, in which landlocked countries are impeded from trade, and particularly so if neighboring countries with access to the sea have not developed their infrastructure; bad governance in a small country, in which corrupt or abusive governments produce economic stagnation and collapse. No doubt these are important factors in understanding cross-national variation in wealth and economic development. However, focus on these factors alone neglects a more encompassing model that includes both ultimate and proximate causation, and does not explain broad, geographic patterns in the wealth of nations.

The conflict trap explains that conflict begets conflict, but the parasite-stress theory of intrastate conflict clarifies how countries at equatorial latitudes generally came to be those that fell into this trap, rather than countries at more temperate latitudes. [Collier's (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b9) latter three traps (the natural resources trap, landlocked with bad neighbors, bad governance in a small country) likely also play an intermediary role in the relationship between infectious disease, national wealth, and ultimately conflict. [Collier (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b9) addresses the squandering of natural resource wealth in patronage politics, but he argues that strong democratic institutions can prevent the typical boom and bust experienced by countries lacking these institutions, specifically contrasting the fate of Nigeria's oil wealth to that of Norway. Although whether a country is landlocked or not may come down to geographical luck of the draw, [Collier (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b9) argues that the obstacles to trade posed by lack of access to the sea are mitigated by having neighbors that have made investment in the infrastructure necessary to facilitate trade, specifically contrasting Uganda and its neighbors to Switzerland and its neighbors. Degree of democratization and liberal values, including equality and willingness to invest in infrastructure and other public goods to be shared across groups, varies systematically with geography, and is accounted for in large part by variation in the intensity of infectious disease ([Thornhill et al., 2009](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b58)). Thus, we propose a “disease trap” that feeds a diversity of factors, including those identified by [Collier (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b9), that lead to economic stagnation, poverty, and conflict. Similarly, such a disease trap likely contributes to the diversity of social ills, such as low life expectancy, poor health and education, and violence, attributed by [Wilkinson & Pickett (2009)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b61) to inequality at the national, state, and local levels.

The influence of parasites on national wealth ([Gallup & Sachs, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b26); [Price-Smith, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b48)) offers an explanation for the pattern of greater wealth in cooler nations, in addition to a cogent explanation that synthesizes a great deal of previous research on the differences in rates of intrastate armed conflict and civil war among nations. There is some debate over the direction of causality in the association between infectious disease and wealth ([Price-Smith, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b48); [Sachs & Malaney, 2002](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b49)). We agree with [Sachs & Malaney (2002)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b49) that causality likely runs in both directions. The morbidity caused by infectious disease incapacitates workers and depresses economic growth. In return, national wealth makes possible investment in public health infrastructure, including clean water sources and effective sewage systems, that can reduce the incidence of infectious disease. Similarly, there is debate about the direction of causality of the well-known association between individualism and national wealth (reviewed in [Gelfand et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b28)). We argue that it is individualism that leads to greater wealth, through greater willingness to invest in public welfare and infrastructure in individualist societies. We suspect there is a further indirect feedback of wealth into individualism, as investment in public health reduces the intensity of infectious disease. Although we argue that the direct causal link is individualism's effect on wealth, this indirect link may have played an important role in the liberalization and secularization of Western societies over the past century (see [Norris & Inglehart, 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b45), for patterns of secularization; see [Thornhill et al., 2009](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b58), for discussion of the role of public health on liberalization of values).

A number of scholars have specifically addressed the question of civil war in Africa. [Collier & Hoeffler (2002)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b10) found that Africa fits into a global pattern of behaviour, with its poor economic performance leaving it prone to civil war. Likewise, [Elbawadi & Sambanis (2000)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b15) found that Africa's high frequency of civil war results from its high levels of poverty. Our findings agree, with respect to civil war per se; we argue that Africa's low economic performance and high levels of poverty are the result of severity of infectious disease stress. Additionally, we find that intrastate armed conflict in Africa, and elsewhere, is a direct result of infectious disease stress, and its evocation of xenophobic and ethnocentric cultural values. The climate of much of Sub-Saharan Africa is particularly conducive to infectious diseases that lead to the development of collectivist values, and thus to widespread poverty. Additionally, as Africa is the place of origin of the human species ([Templeton, 2002](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b57); [Finlayson, 2005](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b25)), the pathogens endemic to Africa have had a particularly long period of antagonistic coevolution with humans. As a result, the diversity of parasites, and associated intensity of human infectious disease, in Africa may be even greater than in other similarly tropical regions. The ancient ancestors of the modern residents of those regions (e.g. southeast Asia, tropical South America) may have escaped some of their most virulent parasites when they migrated through more temperate regions that do not support high parasite richness ([Guernier et al., 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.2010.00133.x/full#b32)).

#### Disease leads to ethnocentrism and xenophobia- causes civil war

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1.

Cross-national variation in the intensity of human infectious diseases produces variation in cultural norms and values. In countries with high intensity of infectious disease stress, cultures are characterized by ethnocentric and xenophobic values. This value system functions in the avoidance and management of exposure to novel pathogens which may be carried by out-group members. In addition to the relative poverty caused directly by infectious disease and the associated mortality and morbidity, xenophobic and ethnocentric cultures remain relatively impoverished because of unwillingness to make investments in public goods that will be shared across social groups within a nation. Resource deprivation, in combination with unwillingness to resolve competition and conflict between groups in a cooperative manner, leads to increased frequency of intrastate armed conflict and civil war in countries with high intensity of infectious disease.

2

Warfare likely does cause subsequent outbreaks of infectious disease, decreases in GDP per capita, political instability, and other factors that are also implicated as causes of warfare themselves. Nevertheless statistical methods common to analysis of the onset of intrastate conflict allow examination of these factors prior to the outbreak of conflict, by eliminating endogenous effects from correlational analyses. Infectious disease stress makes a causal contribution to the occurrence of intrastate armed conflict.

3

It is infectious disease stress that is the causal agent in this model. Climatic factors produce cross-national variation in the intensity of infectious disease. This variation produces cultures that are characterized by more or less ethnocentrism and xenophobia. Countries characterized by high ethnocentrism and xenophobia experience greater frequencies of intrastate armed conflict and civil war.

## Warming- War

#### Warming destabilizes regions, causing skirmishes over food, fresh water, and energy

(Peter Schwartz, futurist, author, and cofounder of the [Global Business Network](http://en.wikipedia.org/wiki/Global_Business_Network), an elite corporate strategy firm, specializing in future-think and scenario planning, and Doug Randall, expert on strategic planning, scenario thinking, networking, strategic communications, and complexity management, BA from University of Pennsylvania, “An Abrupt Climate Change Scenario and Its Implications for United States National Security”,12/03, <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA469325>)

In this report, as an alternative to the scenarios of gradual climatic warming that are so common, we outline an abrupt climate change scenario patterned after the 100­ year event that occurred about 8,200 years ago. This abrupt change scenario is characterized by the following conditions: • Annual average temperatures drop by up to 5 degrees Fahrenheit over Asia and North America and 6 degrees Fahrenheit in northern Europe • Annual average temperatures increase by up to 4 degrees Fahrenheit in key areas throughout Australia, South America, and southern Africa. • Drought persists for most of the decade in critical agricultural regions and in the water resource regions for major population centers in Europe and eastern North America. • Winter storms and winds intensify, amplifying the impacts of the changes. Western Europe and the North Pacific experience enhanced winds. The report explores how such an abrupt climate change scenario could potentially de-stabilize the geo-political environment, leading to skirmishes, battles, and even war due to resource constraints such as: 1) Food shortages due to decreases in net global agricultural production 2) Decreased availability and quality of fresh water in key regions due to shifted precipitation patters, causing more frequent floods and droughts 3) Disrupted access to energy supplies due to extensive sea ice and storminess As global and local carrying capacities are reduced, tensions could mount around the world, leading to two fundamental strategies: defensive and offensive. Nations with the resources to do so may build virtual fortresses around their countries, preserving resources for themselves. Less fortunate nations especially those with ancient enmities with their neighbors, may initiate in struggles for access to food, clean water, or energy. Unlikely alliances could be formed as defense priorities shift and the goal is resources for survival rather than religion, ideology, or national honor.

## Warming- Disease

#### Warming propagates diseases

(R. Shope, Yale Arbovirus Research Unit at the Yale University School of Medicine, “Global climate change and infectious diseases”, Environmental Health Perspectives, 12/91, <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1568225/>)

The influence of climate and the environment on infectious diseases has been a subject of debate, speculation, and serious study for centuries. Jacob Henle (I) stated in his 1840 treatise On Miasmata and Contagia "Heat and moisture favor the production and propagation ofthe infusoria and the molds, as well as the miasmata and contagia, therefore miasmatic-contagious diseases are most often endemic in warm moist regions and epidemic in the wet summer months." He included cholera and yellow fever among the miasmatic-contagious diseases, and indeed these two diseases may have a resurgence, as global warming materializes. For a discussion of global climate change and its possible effect on infectious diseases, I shall deal necessarily in hypothetical terms. There is no way ofknowing for certain what effect, if any, a rise in temperature and a change in rainfall patterns will have. It is feasible, however, to review the literature and point out where warmer temperatures and increased or decreased rainfall favor transmission of certain pathogenic infections; then the epidemiology of these infections can be dissected to see where the temperature and rainfall are critical to the success of the agent. It is convenient to adopt the terminology used by Jaques May (2) in his book The Ecology ofHuman Disease. He considers each transmissible disease a complex. Those that involve only the causative agent and man are two-factor complexes; those that involve in addition a vector are three-factor complexes; and those that involve yet an intermediate host are four-factor complexes. The ambient temperature will have an influence on each of the factors in the complex. Many of the two-factor complexes are not limited by temperature and therefore are distributed anywhere in \*Yale Arbovirus Research Unit, Yale University School of Medicine, Box 3333, New Haven, CT 06510. the world that the agent is introduced and that is inhabited by people. Examples are poliomyelitis and measles. The distribution, prevalence, and severity ofthese diseases are not expected to be modified by global climate change. One could argue that mortality rates ofmeasles and poliomyelitis are higher in the tropics than in the temperate zones, and therefore these diseases will become more severe. The increased severity in the tropics is probably related to poorer socioeconomic conditions. To the extent that global warming increases poverty and its associated ills, the two-factor complexes will also be affected. The three- and four-factor complexes by definition include the vector-borne diseases and zoonoses. Only rarely is a given vector-borne disease distributed everywhere people live. These diseases are usually limited in their distribution, either by the range of their vector, or by that of a reservoir vertebrate host. The vector and host in turn are limited in range directly or indirectly by temperature and rainfall. Yellow Fever and Dengue If I had to guess which vector-borne diseases would pose the greatest threat in case of global warming in North America, I would say those transmitted by Aedes aegypti mosquitoesyellow fever and dengue. Both diseases are caused by viruses of the family Flaviviridae. There is a single yellow fever serotype and four serotypes ofdengue. In the days of sailing ships, Aedes aegypti mosquitoes flourished in the water storage vessels on board and were transported each spring north to the Atlantic coastal cities. Dengue in Philadelphia was described in 1780 by Benjamin Rush, and yellow fever epidemics occurred as far north as Boston. This history is important in the context of global warming because the limiting factor in these epidemics was the onset of cold weather. Aedes aegypti is killed rapidly at freezing temperatures; 62% of adults died when exposed for 1 hr at 32°FR. SHOPE (3), and in a study in Georgia, most larvae died when average weekly ground temperature dropped to 48F (4). The northernmost winter survival of Aedes aegypti is now about 350 N latitude, or the latitude of Memphis, Tennessee. This distribution is predicted with global warnming to move northward and encompass additional large population centers, the numbers depending on how much warming occurs. In addition, the development ofmosquito larvae is faster in warm climates than cold ones, and thus with global warming, the mosquito will become a transmitting adult earlier in the season. The extrinsic incubation period of dengue and yellow fever viruses also is dependent on temperature. Wihiin a wide range oftemperature, the warner the ambient temperature, the shorter the incubation period from the time the mosquito imbibes the infective blood until the mosquito is able to transmit by bite. The implication is that with warmer temperatures in the United States, not only would there be a wider distribution of Aedes aegypti and faster mosquito metamorphosis, but also the viruses ofdengue and yellow fever would have a shorter extrinsic incubation period and thus would cycle more rapidly in the mosquito. A more rapid cycle would increase the speed ofepidemic spread. Persons infected with dengue are entering the United States on a regular basis. In 1987, the diagnosis was confirmed by the Centers for Disease Control in 18 cases by laboratory examination (S). These persons were ill in 10 states and the District of Columbia, and all were presumably infected outside of the United States. Three of these were from Florida and Georgia, states with Aedes aegypti. Table 1 shows the numbers ofimported cases of dengue infection over an 11-year period. All four serotypes have been recognized. Importation of dengue cases continues; as recently as 2 months before this conference, we identified dengue type 1 virus from the blood of a man returning to New Haven, Connecticut, from Thailand. We isolated the same serotype simultaneously from the blood of his travelling companion hospitalized at New York Hospital. Another vector of dengue virus, the Asian tiger mosquito Aedes albopictus, has recently been introduced to the United States from Asia. This mosquito has established itself in scattered foci as far north as 420 N latitude. With global climate change, predictably this vector will become more prevalent and extend its range even further north, thus compounding the risk ofdengue transmission. One may argue that global climate change will be associated with large areas ofdrought, thus Aedes aegypti will not have sufficient water in which to breed. Paradoxically, this mosquito thrives both in wet and dry climates. In dry areas, people store water in their homes. The mosquito is domestic and breeds readily in cisterns and water storage jars. How serious are yellow fever and dengue? Yellow fever is a febrile hemorrhagic disease characterized by hepatic and renal failure. Between 20 and 50% ofvictims with the severe form die, although recovery, when it occurs, is almost always complete. Dengue is usually a nonfatal illness with fever, rash, and protracted malaise. A severe form of dengue with hemorrhagic fever and shock syndrome is described principally in persons suffering a second infection with a different serotype. Most of the hemorrhagic fever cases are in children, and the case fatality rate is about 5%. An effective vaccine is available for yellow fever, but there is no specific preventive immunization for dengue. Virgin Islands, and Pacific Territories. bCases were imported into the United States except for 1980 when indigenous transmission occurred. To summa, we know the following: a) Aedes aegypti mosquitoes are prevalent in the southern United States as far north as latitude 350 N. Temperature is a factor limiting northward spread. This species thrives in both wet and dry climates. b) Aedes albopictus mosquitoes have recently been introduced into the U.S. and range as far north as latitude 420 N. c) Aedes aegypti is an effective vector ofyellow fever, and both mosquito species are effective vectors ofdengue. The extrinsic incubation period ofdengue and yellow fever viruses is shortened by higher ambient temperatures, leading to more rapid amplification of epidemic spread. d) All four serotypes ofdengue virus have been introduced into the United States in recent years, and introduction is a regular occurrence that can be expected to continue. e) Yellow fever and dengue are serious diseases. There is no vaccine for dengue. Cholera Let me turn now to a very different disease, cholera. It is different because it is considered to be a two-factor complex-agent and human being. Cholera behaves ecologically, however, like a three-factor complex. There is growing evidence that a reservoir for this disease exists in bays and estuaries and that such a reservoir encompasses the Gulf Coast of the United States (6). Cholera is characterized by profuse, watery diarrhea leading to loss ofbody salts and severe dehydration. The disease is rapidly fatal in a high percentage ofpatients if fluid and salt replacement is not immediately available. The causative agent of epidemic cholera is a bacterium, Vibrio cholerae serogroup 01, that is motile and grows aerobically at 37°C. Cholera has been known for centuries in the delta of the Brahmaputra and Ganges rivers. Since the beginning ofthe nineteenth century there have been seven pandemics in which the Vibrio cholerae spread rapidly from endemic foci, usually in Asia, to Africa, Europe, and sometimes to North America. Once an epidemic starts, transmission is by fecal-oral spread from carriers recovered from the disease and from asymptomatic, infected persons. Since 1973, repeated episodes of cholera in persons living in the GulfCoast focus of Louisiana and Texas, and in persons consuming raw oysters from Louisiana, have been recorded. In August 1988, cholera occurred in a man in Colorado who ate oysters harvested in a bay off the coast ofLouisiana (7). Between August and October of 1988, persons in five other states de- 172CLIMATE CHANGE AND INFEC7TOUS DISEASES 173 veloped cholera, presumably from oysters harvested in the same area. Comparison ofthe cholera toxin gene sequences using a DNA probe (8) confirmed that the strains of Vibrio cholerae coming from Louisiana were very similar to each other over a span of several years, and that these isolates differed from those ofother parts ofthe world. Thus the evidence is strong that there is a continuing focus of the agent in Louisiana and that the multiple episodes of disease do not represent repeated introductions. What does cholera have to do with global climate change? Louisiana has 40% of the coastal wetlands. With a rise in sea level and perhaps diminished river flow rates, the bays and estuaries of Louisiana can be expected to undergo major modifications. The temperature, pH, salinity, and composition ofplant and animal life may well change drastically. The focus of Vibrio cholerae may thrive or may disappear as a result of these changes; we cannot count on its disappearance, however. May (2) has plotted the areas of cholera expansion in pandemics ofthe nineteenth century. These were summer outbreaks and lay between summer isotherms of60° and 80°F and summer isohyets of2 to 4 inches per month ofrain. Little is known about the relation of Vibrio cholerae to the ecology of estuaries harboring the agent in the United States. Colwell and associates (9) have made a start. So far, no aquatic animal reservoir has been found, although persistence in shellfish for several weeks has been demonstrated. A better understanding ofthe ecology would help us predict the effect of global climate change and prepare us to react. Other Diseases Dengue, yellow fever, and cholera are not the only diseases that probably will be affected. Predictions ofthe effects ofglobal warming include relatively severe modifications of some ofour forests. As forest habitats decline, so will many of the more fragile species of insect vectors and vertebrate hosts ofparasitic, bacterial, and viral infections. We may, for instance, experience a gradual decline in prevalence of LaCrosse encephalitis virus that depends in part on tree-holes of hardwood forests for breeding of its vector, Aedes triseriatus, and for maintenance of its vertebrate hosts, squirrels and chipmunks. Wemay also experience a decline in Lyme disease, caused by Borrelia burgdorferi, a spirochete transmitted by the tick, Ixodes dammini. Tick populations are dependent in their adult stage on deer for their blood meals [although deer population reduction does not always lead to reduced tick populations (10)], and deer populations are dependent at least in part on forests for browsing and cover. Finally, one must consider the possibility of emergence of new infectious diseases. New diseases have continually appeared, and there is no reason to doubt they will continue. Lyme disease, first recognized in 1975 (11), is now the most prevalent tick-borne disease in the United States. The agents of such diseases are not actually new. They have been present in natural wildlife cycles, and it is the ecology that changes, bringing the agent in contact with humans. The relatively rapid ecologic changes that are now predicted set the stage for a speeding up of the process. As change occurs, creatures extend their distribution and overlap occurs. In the special case of segmented genome viruses, ecological overlap ofpopulations creates an abundant opportunity for reassortment of genes that could increase the virulence of the progeny virus (12). There is no way to anticipate these events, but their potential argues for maintaining a strong biomedical infrastructure and watching closely for new diseases. Recommendations What can we do now to prepare for the changes in climate that are expected? I have used examples of infectious diseases that may increase in prevalence or severity. Each of these depends on a reservoir, either a vector, a vertebrate host, or an environmental source, for its maintenance. We know from experience that these diseases have the potential to become epidemic when the ecology changes. We do not know how the ecology will change over the next 50 years, nor do we know enough about the ecological factors essential for the generation of epidemics of each disease. The first recommendation, therefore, emphasizes the importance ofecological studies. These should be multidisciplinary, involving botany (including forestry), zoology, entomology, microbiology, hydrology, climatology, and epidemiology. The information we need to project what will happen with climate change can best be acquired in the field, studying survival and adaptation, especially at the fringe ofthe distribution of species of plants, vertebrate animals, and arthropods. Confirmatory laboratory studies will also be needed, especially of arthropod vectors and the interaction of infectious agents with the vector. These laboratory studies will involve survival ofthe vector and infectious agent under changed temperature and humidity and ability ofthe agent to multiply or go through its development cycle in the vector under changed conditions. The ecology ofwater systems that harbor cholera organisms should also be studied. With the information gained, we should be in a better position to project what will happen with specific diseases after global climate change.

#### Vector borne and water borne diseases will thrive off of effects of warming

(Claire McGuigan, Rebecca Reynolds, Daniel Wiedmer, London School of Economics Consultancy Project for

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Health The IPCC (2001) has stated that “overall negative health impacts are anticipated to outweigh positive health impacts from climate change”. Of particular relevance to developing countries are health impacts from the spread of vector borne diseases, particularly malaria and dengue, health problems related to water shortages and those related to under-nutrition, given the expected rise in food insecurity outlined above. It is difficult to predict impacts with any certainty given the importance of public health services in determining the health of the population. Added to this are the health impacts of unpredictable natural disasters, including cholera, dysentery, malaria and yellow fever, as outlined above. • Infectious diseases Vector borne diseases such as malaria, dengue, mosquito borne (and tick borne) encephalitis and Lyme disease are all affected by changes in climate. Although mosquitos cannot survive past certain temperature thresholds (and therefore some regions may benefit from temperature increases), it is also clear that warmer temperatures and increased humidity are general factors which will encourage their transmission. Malaria is currently one of the most important public health problems of the developing world with around 2.5 million deaths occurring a year mostly in children (DFID, 2002). In general vector borne diseases are expected to expand to cover new areas in the subtropics, including higher elevations and urban areas (such as Nairobi and Harare, DFID 2002). The spread of cholera may also increase due to ocean warming. Although the IPCC (2001) states that “to date there is little evidence that climate change has played a significant role in the recent resurgence of infectious diseases”, Epstein et al (1998) cite some cases where temperature rises have been linked locally to the rise of mosquito borne diseases. This includes cases in the highlands of Tanzania and Kenya, in Mexico (where dengue fever has been reported) and in Colombia where dengue and yellow fever have been reported at an elevation of 2200m. • Water related health impacts Currently 1 billion people live without access to safe water and sanitation. Increasing water shortages caused by global warming could lead to further declining hygiene and sanitation, a spread of water borne diseases such as cholera and typhoid and a rise in diarrheal and skin diseases and other water related conditions.