

# Environmental consequences of nuclear war

Owen B. Toon, Alan Robock, and Richard P. Turco

A regional war involving 100 Hiroshima-sized weapons would pose a worldwide threat due to ozone destruction and climate change. A superpower confrontation with a few thousand weapons would be catastrophic.

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More than 25 years ago, three independent research groups made valuable contributions to elaborating the consequences of nuclear warfare.<sup>1</sup> Paul Crutzen and John Birks proposed that massive fires and smoke emissions in the lower atmosphere after a global nuclear exchange would create severe short-term environmental aftereffects. Extending their work, two of us (Toon and Turco) and colleagues discovered “nuclear winter,” which posited that worldwide climatic cooling from stratospheric smoke would cause agricultural collapse that threatened the majority of the human population with starvation. Vladimir Aleksandrov and Georgiy Stenchikov conducted the first general circulation model simulations in the USSR. Subsequent investigations in the mid- and late 1980s by the US National Academy of Sciences<sup>2</sup> and the International Council of Scientific Unions<sup>3,4</sup> supported those initial studies and shed further light on the phenomena involved. In that same period, Presidents Ronald Reagan and Mikhail Gorbachev recognized the potential environmental damage attending the use of nuclear weapons and devised treaties to reduce the numbers from their peak in 1986—a decline that continues today. When the cold war ended in 1992, the likelihood of a superpower nuclear conflict greatly decreased. Significant arsenals remain, however, and proliferation has led to several new nuclear states. Recent work by our colleagues and us<sup>5,6</sup> shows that even small arsenals threaten people far removed from the sites of conflict because of environmental changes triggered by smoke from firestorms. Meanwhile, modern climate models confirm that the 1980s predictions of nuclear winter effects were, if anything, underestimates.<sup>7</sup>

The Strategic Offensive Reductions Treaty (SORT) of 2002 calls for the US and Russia each to limit their operationally deployed warheads to 1700–2200 by December 2012. The treaty has many unusual features: warheads, rather than delivery systems, are limited; verification measures are not specified; permanent arsenal reductions are not required; warheads need not be destroyed; either side may quickly withdraw; and the treaty expires on the same day that the arsenal limits are to be reached. Nevertheless, should the limits envisioned in SORT be achieved and the excess warheads destroyed, only about 6% of the 70 000 warheads existing in 1986 would remain. Given such a large reduction, one might assume a concomitant large reduction in the num-

ber of potential fatalities from a nuclear war and in the likelihood of environmental consequences that threaten the bulk of humanity. Unfortunately, that assumption is incorrect. Indeed, we estimate that the direct effects of using the 2012 arsenals would lead to hundreds of millions of fatalities. The indirect effects would likely eliminate the majority of the human population.

## Casualty and soot numbers

Any of several targeting strategies might be employed in a nuclear conflict. For example, in a “rational” war, a few weapons are deployed against symbolically important targets. Conversely, a “counterforce” war entails a massive attack against key military, economic, and political targets. We consider a “countervalue” strategy in which urban areas are targeted, mainly to destroy economic and social infrastructure and the ability to fight and recover from a conflict. In any case, when the conflict involves a large number of weapons, the distinction between countervalue and counterforce strategies diminishes because military, economic, and political targets are usually in urban areas.

Box 1 on page 38 describes how we estimate casualties (fatalities plus injuries) and soot (elemental carbon) emissions; figure 1 shows results. The figure gives predicted casualties and soot injected into the upper atmosphere from an attack on several possible target countries by a regional power using 50 weapons of 15-kiloton yield, for a total yield of 0.75 megaton. The figure also provides estimates of the casualties and soot injections from a war based on envisioned SORT arsenals. In the SORT conflict, we assume that Russia targets 1000 weapons on the US and 200 warheads each on France, Germany, India, Japan, Pakistan, and the UK. We assume the US targets 1100 weapons each on China and Russia. We do not consider the 1000 weapons held in the UK, China, France, Israel, India, Pakistan, and possibly North Korea. (Box 2 on page 40 provides information on the world’s nuclear arsenals.) The war scenarios considered in the figure bracket a wide spectrum of possible attacks, but not the extremes for either the least or greatest damage that might occur.

As figure 1 shows, a war between India and Pakistan in which each uses weapons with 0.75-Mt total yield could lead to about 44 million casualties and produce about 6.6 trillion

# Environmental Consequences Of Nuclear War Scope 28 Ecological Agricultural And Human Effects

**CO Houle**



## **Environmental Consequences Of Nuclear War Scope 28 Ecological Agricultural And Human Effects:**

The Environmental Consequences of Nuclear War, 1988      **Ecological and agricultural effects** Mark A. Harwell, Thomas C. Hutchinson, 1989      Energy Abstracts for Policy Analysis, 1986-07      **Environmental Consequences of Nuclear War, Physical and Atmospheric Effects** A. B. Pittock, 1989 The first volume of a work discussing the state of scientific knowledge of the possible environmental consequences of nuclear war It presents a consensus as to the effects nuclear detonations might have on climate ecosystems and food supply      *Nuclear Winter and Its Implications* United States. Congress. Senate. Committee on Armed Services, 1986      **The Use of Nuclear Weapons and the Protection of the Environment during International Armed Conflict** Erik V Koppe, 2008-04-25 In 1996 the International Court of Justice delivered an Advisory Opinion on the legality of the use of nuclear weapons in which the Court stated that while the existing international law relating to the protection and safeguarding of the environment does not specifically prohibit the use of nuclear weapons it indicates important environmental factors that are properly to be taken into account in the context of the implementation of the principles and rules of the law applicable in armed conflict The present work analyses this conclusion focusing on the question whether or not the use of nuclear weapons during international armed conflict would violate existing norms of public international law relating to the protection and safeguarding of the environment Although the use of weaponry during armed conflict is usually related to the protection of individuals the rapidly emerging appreciation of and the worldwide realization of the intrinsic value of the natural environment as an indispensable asset for the continuation of life including human life on this planet both for present and future generations warrants a thorough and extensive examination of the question of the illegality of the employment of nuclear weapons from the point of view of international environmental protection law The book consists of two parts Part I discusses the historical development and the effects of nuclear weapons Part II discusses the protection of the environment during international armed conflict under *ius in bello* *ius ad bellum* and *ius pacis* Only then is it possible to assess the legality of the use of nuclear weapons under this particular set of rules      **Human Impacts on Weather and Climate** William R. Cotton, Roger A. Pielke, Sr, 1995-04-28 As the world's population rises there is increasing evidence that human activities are having a significant impact on the weather and climate from a local to global scale Human Impacts on Weather and Climate is a non mathematical presentation of the basic physical concepts of how human activity may affect weather and climate This book assesses the current hypotheses and examines whether the impacts are measurable Included are critical evaluations of the scientific status of weather modification by cloud seeding human impacts on regional weather and climate and human impacts on global climate including the greenhouse gas hypothesis Discussions also focus on the modern philosophy of science and its application to determining human impacts on weather and climate Human Impacts on Weather and Climate will be invaluable for upper division undergraduate and graduate courses in meteorology geophysics and earth and atmospheric science as well as for policymakers and readers with

an interest in how humans are affecting the atmosphere An extensive reference list is included Comet/Asteroid Impacts and Human Society Peter T. Bobrowsky, Hans Rickman, 2007-06-10 Leading specialists in various disciplines were first invited to a multidisciplinary workshop funded by ICSU on the topic to gain a better appreciation and perspective on the subject of comet asteroid impacts as viewed by different disciplines This volume provides a necessary link between various disciplines and comet asteroid impacts **Journal of the Royal Society of New Zealand**, 1986-12 **Ocular Radiation Risk Assessment in Populations Exposed to Environmental Radiation Contamination** A.K. Junk, Y. Kundiev, P. Vitte, B. V. Worgul, 1998-10-31 The global medical and scientific communities need to standardize methodologies and agree on minimum criteria to permit inter study comparisons This book develops such standards presenting a series of recommendations that represent the first codification of the manner in which studies should be executed **Nuclear Weapons and Scientific Responsibility** C.G. Weeramantry, 2021-10-11 Several years ago when this work first appeared it had become apparent that scientists who play such a key role in the nuclear enterprise needed to be alerted to the many questions of conscience and legality that were inextricably interlinked with their work These questions lay at the heart of the nuclear weapons problem for whatever the political and military leaders might ordain the manufacture of such weapons was a plain impossibility without the active assistance of the scientific profession Yet no substantive work on this topic had until then been attempted Such a work appeared at that time to be an urgent and important need If the problem was then acute and serious it is even more so now The power of nuclear science has grown and with it has grown the power of the individual scientist to initiate new developments The changes in the world order that have occurred in the intervening years enable individual scientists to hold themselves out as available for employment Those who seek their expertise may include not only governments but other entities as well The power of global destruction that these scientists command renders it imperative that they be alerted on a continuing basis to the problems of conscience that arise Hence the need for a re issue of this work for which there had been many requests from concerned scientists professional groups socially concerned organisations and also from lawyers The book is re issued in its original form but updated by the inclusion of more recent work as contained in extracts from three judicial opinions upon the matter **The Precipice** Toby Ord, 2020-03-24 In this urgent and thrillingly written book there is a case and solution for humanity's last shot at survival Sunday Times Humanity's future is at risk We face existential catastrophes climate change nuclear war and more If we do not act fast to reach a place of safety it will soon be too late Drawing on over a decade of research The Precipice explores the cutting edge science behind the risks we face And it points the way forward to the actions and strategies that can safeguard humanity An Oxford philosopher Toby Ord has advised the US National Intelligence Council the UK Prime Minister's Office and the World Bank on the biggest questions facing humanity In The Precipice he offers a startling reassessment of human history the future we are failing to protect and the steps we must take to ensure that our generation is not the last A book that seems made for the present moment New Yorker

**Resilience and the Behavior of Large-Scale Systems** Lance H. Gunderson, Lowell Pritchard, 2012-06-22 Scientists and researchers concerned with the behavior of large ecosystems have focused in recent years on the concept of resilience. Traditional perspectives held that ecological systems exist close to a steady state and resilience is the ability of the system to return rapidly to that state following perturbation. However, beginning with the work of C. S. Holling in the early 1970s, researchers began to look at conditions far from the steady state where instabilities can cause a system to shift into an entirely different regime of behavior and where resilience is measured by the magnitude of disturbance that can be absorbed before the system is restructured. *Resilience and the Behavior of Large Scale Systems* examines theories of resilience and change, offering readers a thorough understanding of how the properties of ecological resilience and human adaptability interact in complex regional scale systems. The book addresses the theoretical concepts of resilience and stability in large scale ecosystems as well as the empirical application of those concepts in a diverse set of cases. In addition, it discusses the practical implications of the new theoretical approaches and their role in the sustainability of human modified ecosystems. The book begins with a review of key properties of complex adaptive systems that contribute to overall resilience, including multiple equilibria, complexity, self-organization at multiple scales, and order. It also presents a set of mathematical metaphors to describe and deepen the reader's understanding of the ideas being discussed. Following the introduction are case studies that explore the biophysical dimensions of resilience in both terrestrial and aquatic systems and evaluate the propositions presented in the introductory chapters. The book concludes with a synthesis section that revisits propositions in light of the case studies, while an appendix presents a detailed account of the relationship between return times for a disturbed system and its resilience. In addition to the editors, contributors include Stephen R. Carpenter, Carl Folke, C. S. Holling, Bengt Owe Jansson, Donald Ludwig, Ariel Lugo, Tim R. McClanahan, Garry D. Peterson, and Brian H. Walker.

**Biodiversity Change and Human Health** Osvaldo E. Sala, Laura A. Meyerson, Camille Parmesan, 2012-09-26 *Biodiversity Change and Human Health* brings together leading experts from the natural science and social science realms as well as the medical community to explore the explicit linkages between human-driven alterations of biodiversity and documented impacts of those changes on human health. The book utilizes multidisciplinary approaches to explore and address the complex interplay between natural biodiversity and human health and well-being. The five parts examine health trade-offs between competing uses of biodiversity, highlighting synergistic situations in which conservation of natural biodiversity actually promotes human health and well-being, relationships between biodiversity and quality of life that have developed over ecological and evolutionary time, the effects of changing biodiversity on provisioning of ecosystem services and how they have affected human health, the role of biodiversity in the spread of infectious disease, native biodiversity as a resource for traditional and modern medicine. *Biodiversity Change and Human Health* synthesizes our current understanding and identifies major gaps in knowledge as it places all aspects of biodiversity and health interactions within a common framework. Contributors explore potential points of

crossover among disciplines both in ways of thinking and of specific methodologies that could ultimately expand opportunities for humans to both live sustainably and enjoy a desirable quality of life

**The Silicon Cycle** Venugopalan Ittekkot, Daniela Unger, Christoph Humborg, Nguyen Tac An, 2012-09-26 Silicon is among the most abundant elements on earth It plays a key but largely unappreciated role in many biogeochemical processes including those that regulate climate and undergird marine food webs The Silicon Cycle is the first book in more than 20 years to present a comprehensive overview of the silicon cycle and issues associated with it The book summarizes the major outcomes of the project Land Ocean Interactions Silica Cycle initiated by the Scientific Community on Problems of the Environment SCOPE of the International Council of Scientific Unions ICSU It tracks the pathway of silicon from land to sea and discusses its biotic and abiotic modifications in transit as well as its cycling in the coastal seas Natural geological processes in combination with atmospheric and hydrological processes are discussed as well as human perturbations of the natural controls of the silicon cycle

**World Peace and the Developing Countries** Joseph Rotblat, Ubiratan D'Ambrosio, 1986-10-03 Journal of the Royal Society of New Zealand , 1987-03

**Energy Research Abstracts** , 1988

**The Global Carbon Cycle** Christopher B. Field, Michael R. Raupach, 2012-09-26 While a number of gases are implicated in global warming carbon dioxide is the most important contributor and in one sense the entire phenomena can be seen as a human induced perturbation of the carbon cycle The Global Carbon Cycle offers a scientific assessment of the state of current knowledge of the carbon cycle by the world's leading scientists sponsored by SCOPE and the Global Carbon Project and other international partners It gives an introductory overview of the carbon cycle with multidisciplinary contributions covering biological physical and social science aspects Included are 29 chapters covering topics including an assessment of carbon climate human interactions a portfolio of carbon management options spatial and temporal distribution of sources and sinks of carbon dioxide socio economic driving forces of emissions scenarios Throughout contributors emphasize that all parts of the carbon cycle are interrelated and only by developing a framework that considers the full set of feedbacks will we be able to achieve a thorough understanding and develop effective management strategies The Global Carbon Cycle edited by Christopher B Field and Michael R Raupach is part of the Rapid Assessment Publication series produced by the Scientific Committee on Problems of the Environment SCOPE in an effort to quickly disseminate the collective knowledge of the world's leading experts on topics of pressing environmental concern

**Sustainability Indicators** Tomás Hák, Bedrich Moldan, Arthur Lyon Dahl, 2012-09-26 While the concept of sustainability has been widely embraced it has been only vaguely defined and is exceedingly difficult to measure Sustainability indicators are critical to making the broad concept of sustainability operational by providing specific measures by which decision makers and the public can judge progress Sustainability Indicators defines the present state of the art in indicator development It presents a comprehensive assessment of the science behind various indicators while placing special emphasis on their use as communications tools The contributors draw on their experience as academics and practitioners to

describe the conceptual challenges to measuring something as complex as sustainability at local regional national and global scales The book also reviews existing indicators to assess how they could be better employed considering which indicators are overused and which have been underutilized Sustainability Indicators will help planners and policy makers find indicators that are ready for application and relevant to their needs and will help researchers identify the unresolved issues where progress is most urgently needed All readers will find advice as to the most effective ways to use indicators to support decision making

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