NEW YORK LAW SCHOOL

NYLS Journal of International and Comparative Law

Volume 4
Number 2 *Volume 4, Number 2, 1983 (Symposium: Nuclear Arms and World Public Order)*

Article 11

1983

Physical Effects of Nuclear War

Bernard T. Feld

PHYSICAL EFFECTS OF NUCLEAR WAR

*BERNARD T. FELD**

On the cover of the Bulletin of the Atomic Scientists,[1] one may find the so-called "doomsday clock." Its minute hand indicates the degree of danger that the world faces with respect to nuclear war. Presently, the clock stands at three minutes before midnight. To place this in perspective, I should indicate that when the clock was first put on the face of the Bulletin in 1959, it was set at seven minutes before midnight.

1959 was a time when we were just beginning to think about how we should talk to the Russians about putting our nuclear house in order. We first tried to cope with the fact that both the United States and the Soviet Union were already capable of annihilating each other a number of times over. We had to deal with the reality that there was absolutely nothing that either side could do which could prevent the other side from carrying out this kind of nuclear attack. In a sense we were both, as it has been said, in the position of two scorpions in a bottle—both capable of delivering a fatal sting and neither capable of doing anything to stop it. It was, therefore, realized that there could be only one solution to the nuclear dilemma: somehow or other to get rid of this terrible threat that hangs over both of our heads.

Since the late nineteen-fifties and early nineteen-sixties, when it was already very clear that both sides possessed more than enough nuclear weapons to do any possible task that they could be called upon to do, the number, variety and sophistication of these weapons have grown. Both sides have weapons that range in strength from a few hundred tons of TNT to 20 or 50 million tons of high explosive—a range of some five or six orders of magnitude. Both sides have vehicles capable of delivering nuclear weapons either over distances of a few feet or over intercontinental distances, approximately 5,000 miles. In essence, both the United States and the Soviet Union possess arsenals of nuclear weapons of a fantastic variety, capable, as previously noted, of doing anything that one could possibly want a nuclear weapon to do.

---

* Professor of Physics, Massachusetts Institute of Technology; Editor-in-Chief, Bulletin of the Atomic Scientists. Chairman, Executive Committee, Pugwash Conferences on Science and World Affairs.

1. BULL. ATOM. SCIENTISTS. This periodical was founded in 1945 by Hyman H. Goldsmith and Eugene Rabinowitch and is published ten times a year by the Educational Foundation for Nuclear Science, Inc., 5801 Kenwood Ave., Chicago, IL 60637.

At this stage in our history, any thoughtful individual who has considered this problem must conclude that nuclear weapons can have only one possible purpose: deterrence. The first-use of a nuclear weapon of any variety in the context of the two so-called superpowers (or, for that matter, in any other context) would, with a very high probability, call for a retaliation from the other side which might be of the same or greater magnitude. This would call for a second-use by the first side, a second-use by the second side, and so on. The chances, therefore, are overwhelming—I believe in the range of 80 or 90%—that any use of nuclear weapons, at least in the superpower context, would rapidly escalate into a full-scale nuclear war. Such a nuclear war would, of course, have consequences reaching far beyond the territories of the two powers.

I think that it can be said that a large-scale nuclear exchange between the two so-called superpowers would mean the death of hundreds of millions of people on both sides with the annihilation of their major population centers and, of course, the decimation of essentially all of their industrial capability.[2] Even if the exchange were only intended to influence the industrial wealth and military power of the two sides, it would also undoubtedly entail the annihilation of tens or, more likely, hundreds of millions of people because of the intricate relationship between population distribution and industrial and military capability.

Aside from those effects, however, there would be others which would reach far beyond the territories of the two antagonists. The primary such effect, and the one which has received the greatest amount of attention and discussion, is the effect of radioactive fallout. Radioac-

2. Official United States sources and a committee of experts in a 1967 report to the U.N. Secretary-General estimated that the result of a retaliatory response involving approximately 200 low megaton nuclear weapons against the industrial and population centers of a first-strike attacker would be "the elimination of around one-third of the population and two-thirds of the industrial capacity of the nation subjected to such retaliation. These estimates, however, were only for the immediate consequences of nuclear explosions, that is, blast, heat and prompt radiation. They did not include the lethal effects of radioactive fallout or other side effects." Feld, *The Consequences of Nuclear War,* 32 BULL. ATOM. SCIENTISTS 10, 11 (1976).

A 1968 Report of the Secretary-General of the United Nations analyzed the likely effects of a one megaton explosion over the city of Birmingham, England, which, at the time of the study, had an estimated population of one million. *See* S. ZUCKERMAN, NUCLEAR ILLUSION AND REALITY 27-29 (1982). That author summarized the report and concluded that "In short, the explosion of a single megaton weapon over one of the largest cities in the United Kingdom would almost inevitably lead to its total elimination." *Id.* at 29.

tive fallout depends, to a certain extent, on the way in which these weapons are used.

The most likely scenario for the use of these weapons would be an attempt by either or both sides to eliminate the weapons of the other. This scenario applies not only to the side that strikes first, but also to the side that retaliates, because one of the purposes of an immediate retaliation would be to eliminate the remaining weapons of the first. Today, with the huge number of weapons, and the number of independent warheads on each (including multiple independently targeted reentry vehicles (MIRVs)), a given side could initiate an attack on the weapons of the other by using only a fraction of its own and could hold the rest in reserve to be used in some way after the initial attack. Assuming that both sides have a thousand weapons, the use of two or three hundred, each one with between five and ten independent warheads, would be sufficient, with the kind of accuracy now available, to eliminate a very large percentage of the weapons of the other side. This ignores the fact that there are many weapons invulnerable to preemptive attacks, such as those in submarines.

Another scenario that has been discussed frequently depicts a major threat of nuclear war. One side or the other would fear, in a crisis, that the other would use its nuclear weapons first. They would have to face the so-called "use them or lose them syndrome." Behind this syndrome lies the idea that if one country does not use its nuclear weapons, the other will preempt their use. Therefore, there will be a very great temptation, in a time of crisis, for both sides to try to use their weapons before they are lost.

In this scenario, most of the weapons would be aimed at the weapons of the other side. The nuclear explosions would be quite close to the ground and not high in the atmosphere. This assumption is crucial in a discussion of fallout because such a nuclear explosion has the effect of creating a great deal of debris from pulverized buildings and earth. The debris is then carried aloft, spread throughout the atmosphere and eventually "falls out," bringing with it a large amount of radioactivity. It is thus evident that a major effect of a nuclear war would be large-scale fallout downwind of the locations where the explosions have taken place.

A rough idea of the kind of fallout effects that might be expected will bring the horror of such a scenario into graphic relief. A one megaton weapon exploded so that the fireball touches the ground—a "ground burst" explosion—is capable of spreading lethal fallout downwind over an area of approximately 1,000 square miles.[3] The area of

3. *See* S. Drell, Facing the Threat of Nuclear Weapons 7 (1983). "For each one

the United States and that of the most populated part of the Soviet Union are each roughly five million square kilometers. Consequently, the explosion of 5,000 nuclear weapons would be sufficient to cover the entire area of either country with lethal fallout. Appreciable fractions of both Canada and Mexico must be added to the areas of the United States, since the wind knows no national borders. The result is that, as of today, when a full-scale exchange on both sides would involve approximately five to ten thousand megatons of TNT equivalent, a full-scale exchange between the United States and the Soviet Union would cover the entire territory of both nations with lethal fallout.

The effects of nuclear war, however, do not stop here. There would be a longer term effect on the climate,[4] caused by debris which would rise and spread around the earth in its atmosphere, both absorbing and reflecting back the light from the sun. The recent explosion of Mount St. Helens gives one an idea of how this can change the climate pattern on the earth, albeit on a much smaller scale. Mount St. Helens' explosion was equivalent to a single five megaton weapon.[5] That is, roughly speaking, equal to one of the weapons in the arsenal of the United States or the Soviet Union. The effect of the Mount St. Helens explosion—glowing sunsets because of the sunlight reflecting off the volcanic debris and gas—was felt and seen worldwide.[6] This relatively small amount of debris did not markedly affect the climate of the earth, although there was a measurable variation of roughly two tenths of a degree in the average temperature during that time. One thousand times that amount of debris, however, would have a very definite effect on the climate, changing the temperature by several degrees. Such changes in temperature may seem small to us, but could have the effect of melting large portions of the polar ice caps and of flooding the low lying areas of the American and European continents. Much of our

---

megaton [bomb] detonated this ash [radioactive debris mixed with soil], driven by the wind, will typically make 1,000 square miles of the earth's surface uninhabitable to unsheltered humans for several or more weeks." *Id.* For a more detailed discussion of the effects of the detonation of a one megaton bomb, see OFFICE OF TECHNOLOGY ASSESSMENT, CONGRESS OF THE UNITED STATES, THE EFFECTS OF NUCLEAR WAR 27-45 (1980), in which the results of a hypothetical detonation over the cities of Leningrad and Detroit are considered at length.

4. *See generally* REPORT OF THE SECRETARY-GENERAL OF THE UNITED NATIONS, NUCLEAR WEAPONS 90-92 (1980); Feld, *supra* note 2, at 12-13; R. AYERS, ENVIRONMENTAL EFFECTS OF NUCLEAR WEAPONS (1965).

5. *See* Reinhold, *Even to Experts, St. Helens Was Powerful Surprise,* N.Y. Times, May 25, 1980, § 1 at 18, col. 1. "Scientists calculated that the explosion released 500 times more energy than the atomic bomb that destroyed Hiroshima in World War II." *Id.*

6. N.Y. Times, May 21, 1980, at A20, col. 4.

population is at sea level so if the level of the ocean were to rise by even a foot, very large areas could be flooded.[7]

There would also be other large-scale effects. For example, the testing of weapons has had a measurable impact on the amount of ozone in the stratosphere.[8] Ozone is a triatomic form of oxygen produced in the upper atmosphere. It is very important for the absorbtion of the ultraviolet component of sunlight. Ultraviolet light is the component which gives rise to sunburns and has other debilitating physiological effects. If the ozone layers were to be depleted by even 30 or 40% (which is what would happen in an exchange of some 5,000 megatons of high explosives by both sides), the level of ultraviolet radiation in the temperate regions of the earth would rise by a factor of three or four.[9] Should this occur, people could not be outdoors without some form of protection. In fact, it would be much like living in the tropics. If one went outside uncovered, he or she would receive intolerable amounts of ultraviolet radiation from the sun. One could not go without dark glasses because of the ultraviolet effects on the retina. Animals would be blinded unless they were all provided with sunglasses, an unlikely prospect.

The last long-term effect to be treated herein is the general rise in the radiation level all over the world. As previously noted, much of the debris created by an explosion is taken up in the stratosphere and deposited randomly across the entire globe. The net effect, for example, of a total exchange of 10,000 megatons is that every person in the southern hemisphere, a region completely uninvolved as a direct participant in the aggression, would each receive somewhere between five and ten radiation units.[10] For the sake of clarification, everybody on

---

7. It should be noted that the climatological effects of large-scale nuclear war are not fully understood. Some research has indicated that average global temperature would be reduced by a few tenths of a degree centigrade for several years. *See* REPORT OF THE SECRETARY-GENERAL, *supra* note 4 at 92. *See generally* NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES, LONG-TERM EFFECTS OF MULTIPLE NUCLEAR-WEAPONS DETONATIONS (1975).

8. *See* OFFICE OF TECHNOLOGY ASSESSMENT, *supra* note 3, at 112-14.

9. Although the precise extent to which a large-scale nuclear war would deplete the ozone layer is not entirely understood at present, it is clear that nitrogen oxides would be released into the upper atmosphere and through chemical reactions, would partially destroy the ozone layer in the stratosphere. REPORT OF THE SECRETARY-GENERAL, *supra* note 4 at 91.

10. *See id.* at 90.

> Extensive early fallout (i.e. from surface bursts) over nations not directly involved in a 10,000 megaton nuclear war may . . . occur. To quantify estimates of short- and long-term radiation injuries from this fallout is much more difficult than for global fallout, as they depend on meteorological conditions and protective measures taken. Under adverse conditions, cases of late cancers and heredi-

earth receives on the average of 1/6 of a radiation unit per year from ambient cosmic rays. Over a lifetime of fifty years, one would receive approximately 8 radiation units. In a nuclear war of limited duration, all inhabitants of remote regions would receive, in a short period, roughly double the lifetime dosage. Double the dosage means that there would be double the number of stillborn children, double the number of children born with deformities and double the number of cancer victims.[11] In fairness, however, it must be noted that the human species could undoubtedly survive the doubling of the physical effects of the normal background radiation.

At the rate at which nuclear weapons are being accumulated, however, in approximately ten years, the number of radiation units to which one could potentially be exposed in a nuclear exchange will have multiplied by a factor of ten. If there were a nuclear war sometime in the 1990's, therefore, a full-scale nuclear exchange would release not five to ten radiation units, but approximately fifty to one hundred radiation units worldwide. Because this is a larger dose than the lifetime accumulation normally to be expected, many people would become sick; but even this dose may not be lethal, at least in the short run.

Even though people would be able to survive, it has been questioned whether or not the species could survive in the long run because of damage to the gene pool. Radiation effects are mainly detrimental to the possibility of procreation so it is not certain that the *human species* could survive a worldwide 50 to 100 radiation unit exposure. If we extrapolate this over another ten years, a nuclear war will expose people to between two hundred and one thousand radiation units per individual. If we keep increasing the nuclear stockpile at the current rate, this kind of guaranteed lethality is something which we could anticipate around the year 2000 or 2005.

A nuclear war in which this level of radiation is released would be fatal to the human species. This degree of radiation represents a human limit. I have termed the degree of radiation from a nuclear war which would doom the species, "one beach." The term is taken from the famous play by Nevil Shute, *On the Beach*,[12] which depicts the destruction of the human species in a final nuclear war. One beach, which is the amount of nuclear explosive which would ensure the elimination of the human species, involves approximately one million mega-

---

tary defects would run into some millions.

Id.

11. *See generally* Drell & von Hippel, *Limited Nuclear War*, SCI. AM., Nov. 1976, at 27; *Effects of Limited Nuclear War: Hearings Before the Subcomm. on Arms Control, Int'l Organizations, and Security Agreements*, 94th Cong., 1st Sess. (1975).

12. N. SHUTE, ON THE BEACH (1957).

tons of TNT. We are now within a factor of 100 of this, which can be either a source of satisfaction or a source of concern. At the rate at which the human species is increasing the accumulation of nuclear weapons, however, we are due to arrive at the beach level sometime in the early part of the next century. Of course one of the major endeavors, if not *the* major endeavor of all concerned with the survival of our species, must be to ensure that this beach scenario will never be achieved.