With the skies black and the temperatures below freezing, vegetation wasted and birds and animals blinded by radiation, there can be no cheer for the survivors. Norman Myers considers the biological consequences of nuclear war.

After the ball is over

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AN EAST-WEST nuclear exchange — even a war of moderate scale, not an "all buttons pressed" affair — could kill between 750 million and 1.1 billion people in the northern hemisphere during the actual conflict. It could also leave at least half as many people severely injured or suffering from radioactivity during the immediate aftermath — and unlikely to receive any succour.

But there would still be a good few in the northern hemisphere to pick themselves up off the ground and try to remain standing. As for communities in the southern hemisphere, the impact of a northern nuclear war could be quite limited in immediate sense.

Such, at any rate, has been the conventional wisdom among many political leaders, military planners, civil defence experts and others who seek to determine our destinies in a post-nuclear world. Now it appears, as a result of wide-ranging studies conducted by international teams of scientists, that great numbers of people could die during the course of the first year after the main battle ends. Indeed their eventual total could match those who perish in the immediate aftermath of the war. As for the remainder, they could well find their lifestyles set back to a level akin to the Middle Ages — and many could even find themselves reduced to the status of hunter-gatherers (if indeed they know how to undertake such an activity). In short, the long-term environmental repercussions of nuclear war could prove at least as severe

Let us look at a 5,000-megaton scenario, or well under half of the projected 1985 nuclear arsenals of the superpowers. A one-megaton bomb is equivalent to 80 Hiroshima bombs, and can contain more explosive power than that of all explosives used in all wars since gunpowder was invented. Not surprisingly, then, a warhead of just one megaton could "vaporise" 100,000 tons of rock and soil, while the total debris it could loft high into the atmosphere, even into the stratosphere, could amount to around one third of a million tons.

At the same time, bombs directed not only at missile sites and other military targets but at urban centres, industrial installations and oil fields would send out sufficient heat to set fire to forests and croplands on a large scale, thus throwing vast amounts of soot and ash into the troposphere and beyond. Forest fires could account for some 400,000 square miles in the northern hemisphere, equivalent to the combined territories of Sweden, Norway and Denmark; large as this amount may sound, it is no more than 4 per cent of all forests in the main combatant countries, and is only about 20 times larger than what is now accounted for by wildfires each year. These fires could well persist for weeks, releasing as much as 200 million tons of extremely fine and light-absorbing particles.

There would also be much similar material hurled upwards from burning oil fields, gas wells and petroleum refineries, as well as from cities with their masses of flammable plastics and other petroleum-derived products. Fossil-fuel dumps, often located near cities, contain at least 1,500 million tons of oil.

All this debris is estimated to be capable of reducing sunlight reaching the Earth's surface by as much as 99 per cent during the first six weeks or so, meaning that noontime would appear like a moonlit night. The extended twilight would probably endure for at least another six months, followed by a further eight months or so of only half-normal light. Of course these predictions are no more than informed estimates, and are not so soundly documented as the immediate damages of a nuclear holocaust. They are presented as carefully-analysed assessments of some broad-ranging repercussion.

As the sunlight became blocked out, temperatures would plunge, to as much as minus 43C in the heartlands of continents. This frigid regime would likewise persist for half a year or so, and more than two years could pass before temperatures revert to normal.

As a result of the darkness, photosynthesis would be suspended. In addition, the extreme cold would cause vegetation in much of the northern hemisphere to die. Thus there would be an immediate halt to organised agriculture as we know it.

Moreover, croplands would suffer further from radioactive fallout. A one-megaton explosion leaves a lethal radioactive "footprint" some 15 miles wide and as much as 150 miles long. If we are to envisage thousands of detonations, vast territories could be subject to potent radiation — an estimated 30 per cent of mid-latitude regions in the northern hemisphere. Generally speaking, plants withstand radiation better than animals. Several crops, however, notably maize, barley, rye, oats, beans and peas, tomatoes, and sugar beets, are more sensitive than others, and their yields would fall by at least one half for a lengthy period. At the same time, small-bodied pests, which are relatively resistant to radiation, would survive and thrive.

Trees, moreover, and especially evergreen trees, are unusually susceptible to radiation, while various kinds of ground cover, such as small shrubs and grasses, are less vulnerable. We might well agree with Jonathan Schell, author of The Fate of the Earth, that the outcome would be "a republic of insects and grasses."

Nor would human survivors be able to turn to livestock for sustenance. Most vertebrates, whether domestic or wild, would quickly freeze to death. Were they to live, somehow or other, they would tend to accumulate radioactive isotopes from the plants they eat, becoming too contaminated for people to eat.

Nor would this be all. A nuclear war of the scale postulated here would probably destroy between 30 and 70 per cent of the ozone in the stratosphere. Although the damage could possibly be made good in about 10 years, the injuries during the interim could be extensive, with twice or three times as much intensity of the most harmful portion of the ultraviolet spectrum reaching the Earth (hitherto shielded by the ozone layer). Of course, this increased intensity would not arise until the darkness had faded away but thereafter the consequences could be severe. Under the scenario proposed, a person could not stay outdoors for more than a few minutes without risking sunburn of lethal degree. Although animals and birds would be protected by their fur and feathers, their eyes would swiftly suffer permanent damage to the cornea. Without sight, animals and birds, whether cattle and chickens or deer and sparrows, could not survive beyond a week or two.

Hitherto we have considered primarily the northern temperate zone. What about the rest of the world? Even were the darkness and cold to be confined to the area of conflict, there could will be triggered "pulses" of cold air masses that would penetrate far into the tropics, with all manner of adverse consequences for the biotas, which cannot stand significant changes in their ambient conditions of temperature. As we have seen, however, much of the debris — smoke, soot, dust — would probably be hurled into the higher strata of the troposphere, even beyond into the stratosphere, making more probable the prospect that dense clouds of debris would spread into the northern tropics, bringing with them darkness and extreme cold. Even more damaging is the possibility of interhemispheric mixing, causing a good part of the debris to

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be transported across the equator and into the southern hemisphere.

Were "darkness at noon," with accompanying sub-zero temperatures, to afflict the tropics, the repercussions for plant life could be far more serious than in the northern temperate zone. Tree seeds in the tropics tend to be much more short-lived than those of temperate zones, meaning that tropical forests could rapidly disappear (taking with them a majority of the two-fifths of all Earth's species that occur in tropical forests). Outside the forests, much tropical vegetation, finely calibrated with climatic enviroments, would prove exceptionally sensitive to changes in sunlight and temperature. Third World agriculture, which at the best of times is more of a "survival issue" than in the northern temperate zone, would be critically hit.

Thus human communities of the tropical zones might find that even if they remained on the sidelines during the war, they would still suffer profoundly. Not that they are likely to be untouched by hostilities. Many oil fields, maritime straits and other strategic resources are located in the tropics — plus, of course, the military installations, including thermonuclear facilities, that are becoming ever-more frequent phenomena in the Third World. We can reasonably anticipate that at least 50 megatons, possibly much more, are targeted at places such as the Middle East, India and South Africa, with their strategic centres — and let us remember that 100 megatons are enough to destroy all cities of more than one million people in the world.

To assume an optimistic scenario, suppose that tropical nations remain entirely unaffected. They would nonetheless find that no more of the grain shipments would arrive at their ports, nor any of the fossil fuels, fertilizers, machinery and other imported resources that most Third World countries need to maintain their agriculture. Those countries that tread a fine line between food sufficiency and starvation would find their populaces reduced to subsistence agriculture at best.

Due to the synergistic compounding of impacts, we should not consider these various categories in isolation from each other. Rather we should recognise that the cumulative effects will tend to compound each other, until the overall impact becomes far greater than the sum of individual impacts. Let us consider, for example, what is likely to be the principal preoccupation in a post-war world, the restoration of modern agriculture. During the dying off of vegetation, there will have been widespread erosion of topsoil, together with loss of nutrients — yet fuel for tractors, ploughs, irrigation pumps and the like will be unobtainable, as will fertilisers of the conventional synthetic sort. There will be unusually severe outbursts of pests, yet chemical pesticides will no longer be available. The last environmental factor to settle down could well be weather (the instability due to, for instance, increased albedo), with unexpected floods and drought, yet there will be no stocks of genetically adapted crop seeds. There will be a series of adverse circumstances that reinforce each other, making a recovery for modern agriculture difficult for a good many years.

In a recent paper prepared by 21 biologists and ecologists, eminent in their fields around the world, the overall finding was: "Whether any people would be able to persist for long in the face of highly modified biological communities; novel climates; high levels of radiation; shattered agricultural, social and economic systems; extraordinary psychological stresses; and a host of other difficulties, is open to question.

"It is clear that the ecosystem effects alone resulting from a large-scale thermonuclear war could be enough to destroy the current civilisation in at least the northern hemisphere. Coupled with the direct casualties of perhaps two billion people, the combined intermediate and long-term effects of nuclear war suggest that eventually there might be no human survivors in the northern hemisphere. In almost any realistic case involving nuclear exchanges between the superpowers, global environmental changes sufficient to cause an extinction event equal to or more severe than that at the close of the Cretaceous are likely. In that event, the possibility of the extinction of *Homo sapiens* cannot be excluded."

Dr Norman Myers was one of three British scientists, and one of seven scientists from outside the US, invited to participate in two preparatory workshops in Cambridge, Massachusetts, in early May this year, the findings of which were presented at a Conference on the Long-Term Worldwide Biological Consequences of Nuclear War, in Washington DC this week.

Bibliography: Paul R. Ehrlich and 20 others, "The Long-Term Biological Consequences of Nuclear War." **Science** forthcoming; R. P. Turco, C. Sagan and three others, "Long Term Atmospheric and Climatic Consequences of a Nuclear Exchange," **Science** forthcoming; J. Peterson, editor, **The Aftermath: The Human and Ecological Consequences of Nuclear War,"** Pergamon Press, Oxford, 1983.