THE LAND AND DEFENCE

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THE LAND AND DEFENCE

The Nuclear Winter

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Introduction

The atmosphere and the climate of the world would change drastically for months after a full-scale nuclear war. Sunlight in the Northern hemisphere would be reduced to a small fraction of its normal level. The temperature would fall enough in the continents to turn summer into severe winter or to turn a temperate winter into severe winter: this is the Nuclear Winter. The Southern hemisphere would be affected, but not so much as the North.

Significant effects would follow the explosion over cities of just 100 Megatons, less than 1% of the arsenals of the superpowers and less than the UK nuclear force alone. An attack on one superpower by the other could wreck its own agriculture, even if there were no counterattack. Through cold and starvation, neutral nations could suffer more dead than those at war.

The atmosphere

The atmosphere consists of many layers with relatively little mixing between them. The lowest layer is the troposphere, which contains almost all the weather. It reaches from ground level up to about 7km (23, 000 ft) at the poles and up to about 20km (66, 000 ft) at the equator. Above the UK it is about 9 or 10km deep.

Above the troposphere is the stratosphere. Dust or smoke in the troposphere is usually washed out in a week or two. In the stratosphere it can last for months, and spreads out over the hemisphere before coming down.

Atmospheric effects

The following is a list of the main effects, with times for them to take place:

1) Nuclear explosions send dust, radioactivity and oxides of Nitrogen (NO_x) into the atmosphere (seconds-minutes).
2) They ignite fires over wide areas, including cities and forests, about 300km^2 (120sq miles) per Megaton (seconds).
3) The fires spread internally (minutes) and externally (hours to months).
4) The fires produce heated air, smoke and gases (carbon dioxide, carbon monoxide, NO_x, water vapour and various poisonous gases such as cyanides and dioxins (minutes to months).
5) Some hot air and gases rise into the upper troposphere and some into the stratosphere, taking smoke with them (minutes to hours).
6) Some of the smoky air is heated by sunlight and rises still higher (days to months).
7) Some of the dust, radioactivity and smoke is washed to the ground; the rest, together with the gases, is carried by winds around the earth (days to weeks).

The intermediate radioactive fallout gives a background dose of about 50rems over a large proportion of the Northern hemisphere.

8) An unbroken layer of smoke forms in days in a band around the earth. It spreads throughout the Northern hemisphere in weeks and into the Southern hemisphere (one or two months).

9) Under the spreading smoke and dust clouds daylight is reduced to darkness (days) twilight (weeks) and severe overcast (months).

10) The drop in temperature in most countries of the Northern hemisphere is more than the difference between summer and a severe winter (months).

11) The NO_X destroys some of the ozone in the stratosphere (weeks to months).

12) After a month to a year the dust and smoke coagulate and fall to the ground. When the sky clears the ground is exposed to damaging ultra-violet radiation, no longer screened by the ozone (years).

13) Temperatures may take years to return to normal or may become exceptionally high. The weather is disturbed for years, but an ice age is unlikely, though possible.

Britain

The principal predictions were made by three American and one Soviet groups, published in Science, or to be published in 'Nature' or elsewhere. The main results are averages over land and ocean in the Northern hemisphere. There could be significant differences between the continental land masses of the USA or USSR on the one hand and an island like Britain on the other.

In a normal winter the oceans are much warmer than the continents at the same latitude. Because we live on an island surrounded by the Gulf Stream, our winters are less severe, and our weather is both more changeable and more unpredictable than in continental interiors. This would also be true of the Nuclear Winter.

But there are some distinguishing features of the Nuclear Winter. For example, the contrast between land and sea temperatures would be much greater than for a normal winter. The likely consequences of this for Britain are strong winds and severe storms, violent changes in temperature, such as sudden and possibly prolonged hard frosts even in midsummer, followed by temperatures depressed by a few degrees C over periods of a year or more, depending on the season of attack.

Summary

A large-scale nuclear war would produce drastic effects on the atmosphere. The Northern hemisphere would be subject to dark, cold, radioactivity and poisonous fumes, followed after a few months by increased ultraviolet light from the sun. The Southern hemisphere would also be affected, though less severely, and significant effects in the Northern hemisphere could follow an exchange as small as 100 Megatons.

THE LAND AND DEFENCE CONFERENCE

Monday 19th March 1984

DEFENCE: A RATIONAL APPRAISAL

Stan Windass
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I THE NUCLEAR MAN-TRAP

In a speech given in Hiroshima in February 1981, Pope John Paul II said, "In the past, it was possible to destroy a village, a town, a region, even a country. Now it is the whole planet that has come under threat. This fact should fully compel everyone to face a basic moral consideration: from now on it is only through a conscious choice and then deliberate policy that humanity can survive."

We have heard today the evidence which supports the Pope's solemn warning; that we now have the choice, for the first time in history, to destroy the human race. This places on us all an awesome and inescapable responsibility - a responsibility which I believe should never leave our minds until, as trustees not only of present but also of countless future generations, that we have chosen life instead of death.

The present stockpile of nuclear weapons is equal to a million Hiroshimas; and we are now busily engaged in fitting the fuse into this stockpile, in the form of highly sophisticated theatre and nuclear weapons in Europe. Pershing II missiles, due to be installed in West Germany, have a very high accuracy and a flight time of ten minutes to the Soviet Union.

That is not to say the Americans are to blame, or the Russians are to blame. It is not to say the Conservatives, are to blame, or the Labour Party is to blame. To play the blame game is the opposite of accepting responsibility. We are all responsible and, to the extent that we fail to accept the responsibility, we are all guilty.

In order to appreciate the danger and the foolishness of our present policies, we have only to consider the words of General Bernard Rogers, Supreme Allied Commander in Europe of NATO. He says, repeatedly, that in his opinion <u>any</u> use of nuclear weapons would be virtually certain to escalate to a strategic nuclear war. At the same time, he says that allied defences in Central Europe are so inadequate that, in the event of a Warsaw Pact tank attack,

he would be forced within four or five days to request release of nuclear weapons from his political masters.

In other words, we defend Western Europe by a threat of racial suicide. Needless to say, the threat lacks all credibility; yet, because of the danger of miscalculation and accident, it is also incredibly dangerous. It is as if we said to the Russians 'Watch out; don't invade us because we, on this side of the border, are mad. This is the great global hi-jack.' But we also have to say something else, in a vain effort to make our defence rational. We have not only to say to the Russians, 'We are mad! We also have to say, 'but we hope to God you are not; because if you are as mad as we are, then you will not be deterred, and we are all programmed for self-destruction.'

It is a strange defence policy for homo sapiens.

Yet we could make no greater mistake than to assume that the people responsible for constructing such a policy were either insane or wicked. On the contrary, they were sane and honourable men; and we all share their responsibility. But we were all working on false assumptions, believing false mythologies. We were caught, and are still caught, in a dynamic which is carrying us rapidly towards a precipice.

What is the nature of this dynamic? What are the mythologies and false assumptions which drive us forward the final catastrophe?

In the 1960's people got used to the idea of MAD - or Mutually Assured Destruction - the idea that each side could annihilate the other in a second strike, and therefore neither would strike. Each possessed as it were a self-cancelling suicide weapon. This was fine as far as it went. But it was of course just a rationalisation of what in fact occurred when Russia acquired intercontinental missiles. Had the matter rested there we might have enjoyed a kind of MAD millenium, a security based on mutual paralysis. But remember that the torrent of scientific advance continues inexorably. Ever new and better weapons are generated and deployed. Bigger, weapons, smaller weapons, more accurate weapons, more versatile weapons - that's after all what 'advance' means in terms of weapons - no-one is going to develop less accurate or less versatile weapons.

What happens then to the theology of MAD? We still need rationalisation, a theory that makes sense - but why add to MAD? You can only be exterminated once! Why should you prepare to exterminate the enemy fourteen times over, and then, as those in the trade charmingly put it, 'bounce the rubble'. If the aim is deterrence by MAD, should we add to all these so-called 'theatre' battlefield nuclear weapons?

Let us take first the smaller so-called 'theatre' and 'battle-field' nuclear weapons - the weapons which are as it were 'underneath' the nuclear umbrella. In order to rationalise or justify these weapons you must say two things, simultaneously. You must say first that you might use these weapons; and secondly that this use might not trigger off a MAD nuclear war. If you would not in any circumstances use the weapons. then obviously there's no point in having them; if their use was certain to escalate to MAD - then there is also no point in having them - you might as well begin at the top! You can't add to MAD. But when you say you might use these weapons, and you might not escalate to MAD, what you are saying is that you might fight a limited nuclear war. And there is no point in fighting a war, unless you can win it, or 'prevail'. So, inevitably, you are forced by sheer logic to talk about nuclear war-fighting and nuclear war-winning strategies which is exactly where both superpowers are at present. As you can't just pretend in the abstract, you must purchase equipment, exercise, train, write your military manuals as if you intended to fight a limited nuclear war. And of course, the technologists are putting into your hands the very weapons which will enable you to do this. Ever more flexible, more accurate, more sophisticated. The doctrine of so-called 'extended deterrence', the downwards extension of MAD, leads straight towards nuclear war-fighting doctrine and capability. And yet nuclear war-fighting is precisely what at all costs we are seeking to avoid.

While nuclear war-fighting doctrine and technology develop on the lower rungs of the ladder, something else is happening to the top rung - our original MAD weapons.

One might have thought that 'enough was enough', and that once each side had sufficient weapons to eliminate the other, the race would end. This however is not the case. The strategic weapons also are developed; they become more accurate and versatile, and the pressure to deploy the improved strategic weapons is immense, just as the pressure to use the lesser weapons was immense; but what military justification could there be for more 'MAD' at the strategic level?

As the strategic weapons develop, a new possibility emerges; that of using them against the enemy's strategic weapons, and his other military installations; using them, that is, for a first strike, which will eliminate the enemy's power to retaliate. Other technological developments help this process forward - especially anti-submarine warfare, by which the enemy's power to retaliate can be limited, and anti-ballistic missiles systems, which can reduce the damage done by nuclear retaliation. Once this possibility is foreseen, then the pressure to achieve a first strike is immense - if only to stop the other side getting there first. This means of course a collosal build-up of strategic weapons, so that the enemy missiles can be 'saturated' - or so that you can avoid your being saturated, and still respond with a 'second strike' sufficient to deter.

It may well be that neither side actually intends to develop and use a first strike capability. The trouble is that once the possibility exists, you are almost bound through the mythology of balance, to become involved in a first-strike race. If you suspect the other side of going for first strike, then you will take counter-measures like developing anti-ballistic missiles systems and multiplying your own missiles. All these defence measures however could mean that you are yourself planning a first strike.

In fact, once the possibility of a first strike is foreseen, there is really no other way forward except to try to achieve it. It is a necessary part of looking as if you could win or prevail in a nuclear war. You can't realistically expect to 'win' a nuclear war at a lower level unless you could win at the higher level too. No country would accept defeat at level 5 on the ladder if it could win at level 6! If you can't win a war, there's no point in fighting one - and if you can't fight one, there's no point in threatening one! This applies to nuclear war the same as any other, and to defensive wars as well as offensive.

There is nothing in the least surprising about this. As long as you think in terms of flexible response and nuclear war-fighting, there is no policy which makes any sense except to be able to win a nuclear war.

If we go on talking the 'old language', we could end with a perfect balance; not a balance of MAD, but a balance in which each side could destroy the other without being destroyed. This would be an exceedingly dangerous situation, since the arguments for using a first strike capability once it was acquired would be hard to resist. Nuclear war, by design, accident or insanity, would become virtually inescapable.

II EMERGING TECHNOLOGY

In order to rethink our defence policy we have to go back to square one. What is it that we are afraid of? What is the actual and effective military threat to NATO? Most people would agree, experts and non-experts alike, that what is feared basically is an invasion of Western Europe from the East, involving massive concentrations of tanks and aircraft. It is when we confront this problem in a rational way, as problem solvers, as people worthy of the name 'Homo sapiens', that we find emerging technology is beginning to offer us some promising solution.

The technology we are talking about is the extraordinary and ever-accelerating advance of small weapons guidance systems, of precision-guided munitions, and of command, control, communications and intelligence. Developments largely based on the same microelectronics, which we know is revolutionising our everyday lives. But this same technology which is transforming all our ideas about, say, education or banking is also making tanks, large warships and large piloted aircraft as obsolete in warfare as horse-drawn canons, or indeed as Hannibal's elephants.

These advances radically affect two things on which the war-game has always depended: the ability to locate the enemy's assets; and the ability to destroy them. Let us take the destroying aspect first.

The latest generation of small precision guided missiles is called "Fire-and-forget". They simply have to be released in the general vicinity of their target and they will themselves search out and navigate to attack tanks, submarines, ships or aircraft in the most vulnerable spot.

In order to achieve this, these precision-guided and terminally guided munitions rely increasingly on 'inbuilt intelligence' - sensors based on infra red, or millimeter wave radiation, image matching, or combinations of these and other 'seeking' modes. Advances in inbuilt intelligence in the next generation are likely to be as prodigious as the advances which have already replaced multi-million pound cumbersome computing machines with pocket calculators available in Woolworths.

The obvious objections to this is that 'countermeasures' can be installed. Tanks, ships and aircraft can be fitted with heavier armour, with decoys, with jamming devices, even with self-healing properties like instant fire exstinguishers operating in microseconds. All this can and is being done. But there is one crucial consideration that is often ignored. We are talking about defence against invasion. Yet without tanks, ships and

aircraft invasion and military takeover are impossible. Invading a well defended country involves moving large numbers of people and large quantities of firepower forward through hostile territory. To do this, you need people-carrying and weapon-carrying machines and platforms (such as tanks, ships and aircraft), and these machines and platforms must be of a certain minimum size, and able to defend themselves. Of course you can try to defend these machines with thick armour, electronic counter measures, and so on, and so on. But at a cost. At a cost in manoeuvrability, complexity, size, fallibility and training. But above all at a financial cost.

Andrew Wilson writing somewhat mischievously in the Observer on 28 August 1983 estimated that by the year 2008 Britain would be able to afford a front line force of only four strike aircraft and two support planes and one and a half naval frigates - one ship for every 5 admirals; one plane for every 4 air marshals. And these futuristic platforms would of course be military dinosaurs. Because of the time it takes to develop these highly complex offensive machines, the technology for destroying them at perhaps one millionth the cost will certainly be in place and fully developed by the enemy.

What we say then is that we must seize this moment in history to advocate in Central Europe a purely defensive system which makes use of all available technology to make it totally impossible for any sane Russian leader to contemplate a military invasion. All this does not of course just mean getting a set of gimmicky 'high technology' weapons. It means a whole system of disposition of troops, training, logistics, forces levels and structure obstacles.

Professor John Keegan of the Royal Military Academy at Sandhurst, is now strongly advocating non-provocative defence in Central Europe, based substantially on what he calls 'altering the geography', using bulldozers, autobahn demolition, instant tank traps, and so on. This kind of system has been called 'Glue on the Western front', designed to make West Germany highly unattractive and inconvenient to uninvited tourists, who arrive in tanks. This is of crucial importance, because it is generally agreed on both sides that if the Warsaw Pact were to lose time, they would lose all advantage.

It is not just 'high technology' we advocate. It is any kind of technology which can achieve the down-to-earth and totally commonsensical objective of effective, affordable and non-provocative defence.

III THE REAL DEBATE

The real debate therefore is not about 'Raising the Nuclear Threshold'. That's like virtue, everyone's for it. It's not even about 'No First (Early) Use'. Nearly everyone agrees about that too - as a fact or a 'goal', if not as a declared principle. Nor is it about the importance of conventional defence and 'E.T.' (Emerging Technology).

The real debate now is about what kind of conventional defence we substitute for our incredible and incredibly dangerous battlefield and theatre nuclear weapons, and for NATO policy which depends on first and early use of these nuclear weapons to repel a Warsaw Pact tank attack. Closely connected with this debate is a problem about the nature of war - and what it means to 'win'.

One school of thought associated with the name 'Airland Battle 2000', would substitute for battlefield nuclear weapons the nearest substitute in offensive conventional weapons - weapons able to carry out a 'deep strike' into Warsaw Pact territory. The theory is that Warsaw Pact tanks would attack in successive waves, and that it is essential to attack and destroy not only the first wave but also the second and third 'echelons'. It is necessary also to be able to destroy airfields many hundreds of kilometers inside enemy territory, to fire 'area denial' weapons across the border in the track of advancing armour, and to destroy troops concentrations, storage facilities and choker-points far to the rear of enemy forces.

But what does it look like from the other side?

NATO, we say, was, and always will be a purely defensive alliance. Our tanks are outnumbered 2.5 to 1 on the Central European frontier. We could not possibly be seen as a threat to the Russians. But could we?

It often is a surprise to people brought up in NATO orthodoxy to find that the Russian political thought and national consciousness is heavily loaded with the fear of invasion from the West. Unlike the Americans or the British in our big and little island homes, the Russians know what invasion is like, having lived through it twice in recent history. If President Reagan fears communist invasion from the impoverished and defenceless people who inhabit the tiny strip of land linking North America to South America, how might the Russians feel about NATO Europe? How might our 'Airland Battle' seem to them?

First of all, seen from their point of view, we are acquiring the capability to destroy vast arrays of Warsaw Pact tanks and aircraft within their own territory, thus 'disarming' them of their defensive counter-attack capability. Secondly, we integrate this capability with nuclear weapons like the highly accurate Pershing II (108 to be deployed, about

300+ already in production, launchers having a reload capability and warheads likely to be 'MIRVED') which can, in the jargon of the trade, be used either to 'decapitate' Russian command, control and communications within ten minutes, or eliminate a large number of Soviet nuclear weapons.

Thirdly, we associate all this with a modernisation at all levels of nuclear weaponry totally unprecedented in the arms race so far (involving a US military budget higher in real terms than at the peak of the Korean and Vietnam wars, and the deployment of 23,000 new nuclear warheads in the 1980s) and with a doctrine which aims at acquiring the ability to 'Prevail at all levels' (in order to defend the West).

It is the job of military to assume the worst case; and an escalation in conventional offensive weapons is likely to strengthen the arguments of the hawks in the Soviet establishment, and thereby accelerate the arms race, thus decreasing our own security.

'Winning wars' can have two meanings.

The first is quite straightforward. It means the armed forces must achieve a military objective - to seize control of a canal, to repel invasion, to rescue hostages, take over military control of a neighbour's territory.

The second meaning of 'win' is quite different. It goes back to the old 'trial by combat' system of the Middle Ages. Winning or losing is strictly defined within the rules of the game, and it does not vary. Thus the jousting knight had to kill his opponent or force a formal submission, just as the chess-player has to checkmate the King, or the tennis-player to 'win' the match.

In military terms, the second meaning of winning is 'to defeat the enemy's armed forces and destroy his will to resist.' (US Field Manual 100/5 p.B1). In this context, 'The offence is the decisive form of war, the commander's only means of attaining a positive goal or of completely destroying an enemy force' (Ibid, p.8-1).

The trouble is that the word 'win' has a mind of its own - a kind of inbuilt bias, like a bowl that always swerves in a certain direction. 'Win' really belongs with 'win or lose' games, and once you start bowling with this word, however straight your aim, you are almost bound to find yourself back in the Middle Ages. You may talk about 'winning and defence', but the words are ill-matched and tend to fall apart; and as for 'winning deterrence', its hard to stick those two words together at all. Which is a pity because defensive deterrence is the only 'war game' in which both sides can win simultaneously.

IV ADVANTAGES OF NON-PROVOCATIVE DEFENCE

In contrast to the pursuit of new generations of 'war-winning' weapons, and the penalties of setting off a new 'E.T. arms race', the deliberate and systematic pursuit of non-provocative defence offers a number of very specific advantages.

(i) First of all, non-provocative defence defuses the arms race. It does this by removing fear, which is undoubtedly a principal motive force of the arms race. Or, if you want more sophisticated formula, non-provocative defence defuses the arms race by cutting away the arguments of the 'hawks' on the other side. It eliminates the only respectable rationale for the accumulation of offensive weapons which is that you face a military threat. Both sides certainly maintain that their military postures are entirely defensive. O.K., why not set about proving it - not only to our own satisfaction, but to that of the other side, even to those on the other side whose job it is to think of the 'worst possible case'. Let us prove it also to World Public Opinion - a force which even super-powers have to reckon with. Of course, we are not saying that by eliminating the rationale of Russian deployment we shall automatically see their tanks melted down into ploughshares. All military establishments are conservative, and the Russians are probably the most conservative of all - and passionately attached to tanks and artillery. Nevertheless, in the long-run removing the perceived threat can do nothing but good.

(ii) Secondly, non-provocative defence is likely to be affordable. Of course defusing the arms race must in the long run bring economic benefits. But even in the short term, non-provocative defence is likely to lead to significant economies.

In general terms the reason for this is quite simple. Clearly the shorter range battlefield weapon systems we are talking about are much cheaper even now than the longer-range, 'deep strike' systems. A recent high-level European Security Study* estimated, in its proposed defensive scenario, that the cost of long-range conventional element would be ten times

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* Strengthening Conventional Deterrance in Europe, American Academy of Arts and Sciences, Macmillan, 1983.

that of conventional short-range defensive elements. At the same time, the reduction of theatre and battlefield nuclear weapons will also bring great reductions in the defence budget, estimated by Admiral Eugene Carroll (formerly Commander-in-Chief of US forces in Europe), as amounting to at least a four per cent saving. In the long-term these economies might increase sharply as the development of semi-custom design and manufacture reduces the cost of micro-electronics. All the indications are therefore that non-provocative defence would save money, while 'offensive' defence would start another lap in the financial arms race, in which each side tries to bankrupt the other.

(iii) Thirdly, non-provocative defence is credible in the sense that the other side would have no doubt that it would be used if he tried to attack, because there could be absolutley no reason not to use it. Because of this, non-provocative defence would be a credible deterrent, and would minimise the possibility of any war in Europe. By contrast, our present policy which is based on first use of nuclear weapons, lacks all credibility, and any policy which relies on a nuclear threat to stop an invasion also lacks credibility. It makes even less sense to cross the nuclear threshold higher up than lower down. With an effective real defence the nuclear system can be seen for what it is, at best a self-cancelling MAD system which has no relation to real defence, and which can therefore be progressivley and systematically dismantled.

(iv) Fourthly, non-provocative defence does not depend on the mythology of balance, nor on agreement with the other side.

It is an extraordinary comment on our clouded perceptions of international affairs that it seems odd to suggest that defence has nothing to do with balance. We picture weighing pans with equal weights on both sides (a good 'scientific' image) and any reduction on either side is thus 'destablising'. Or we picture two giant stones leaning against each other, propping each other up, and we think of this as 'The Military Balance').

Yet the connection between balance and security is far from obvious. Ask any intelligent eight-year-old what he would do if he was afraid of a tank attack and you would get some good answers. He might say he would dig a hole so that it would fall in. He might say he would fire a laser gun at it. Both good answers. But neither answer has anything to do with balance. If he were to say he would defend himself against a tank by

balancing another tank against it, one might suspect that he had been 'got at', and that he did not have an unadulterated eight-year-old intelligence.

If you want to defend your house against burglars, you do not immediately think of filling it with jemmies, masks and burglars equipment. This would hardly deter burglars, but would soon produce a burglarous society, in which everyone would be insecure. Security and balance are simply not the same, and arguments based on that assumption are defective.

Since non-provocative defence does not depend on balance, neither does it depend on reaching agreement with the other side. You don't have to get permission from your opponent to set it up. If such a defence is available, you go ahead and get it - you have everything to gain, and nothing to lose.

(v) Finally, non-provocative defence is JUST in the second sense of the word.

Just Defence means defence without offence, but it also means defence which is just. Defence which is unmistakably in accord with morality, and with international law. Just Defence is based on the UN Charter, and on the right of collective self-defence which is reserved for states in limited circumstances.

At a deeper level it is based on the principle of self-determination of peoples, which is declared in the first article of the UN Charter, and is the main foundation stone of the international order.

Just Defence affirms the right of self-defence not only for you but also for your adversary. It explicitly rejects the right to 'offend', or to invade. It seems providential that at this moment in history, perhaps for the first time, it is now possible to opt for real defence without offence. It is as if the Almighty is using a carrot as well as a stick in a last effort to get his mulish people to move off the railway line before the nuclear express is due. It is time we stopped munching the daisies between the tracks.

Environmental Consequences of Nuclear War.

Norman Myers PhD.

The climatic dislocations of nuclear war would trigger environmental disruption of exceptional scale. This would apply especially to agriculture, and hence to the capacity of survivors to feed themselves. The eventual loss of life through starvation, plus other environmental sources of mortality such as freezing, could even match the immediate casualties of the war itself. As for damage to our natural life-support systems, it could prove as widespread and enduring as the destruction of our techno-resource base.

The most important factor is the pall of smoke and soot, thick enough to block out sunlight and thus to suspend most photosynthesis for months on end. At the same time, temperatures would plunge far below 0 degrees C., so a frigid regime would persist for months on end. This "nuclear winter" would cause vegetation to be severely damaged throughout the northern hemisphere, much of it beyond recovery. Since this would apply especially to crop plants, there would be an immediate halt to organized agriculture as we know it.

The southern hemisphere would experience parallel disruptions, though not so far reaching at first. Thus a nuclear winter, while brought on by a conflict between relatively few nations of the northern hemisphere, would ultimately affect nations everywhere. Since this paper, however, is to confine its attentions to the northern hemisphere, and particularly to Britain, we shall not consider the rest of the world further--except to note that the agricultural repercussions could eventually prove so widespread that there would be severe shortages of food everywhere.

In addition to the nuclear winter, there would be various other environmental assaults that would critically injure vegetation, leaving it less able to sustain the impact of extreme cold and dark. Ionizing radiation would cause widespread harm to plants; and the same for a "smog" of pyrotoxins and other noxious chemicals, also acid rain. When the smoke cloud in the atmosphere eventually dispersed, there would be an increase in ultraviolet radiation at ground level, caused by depletion of the ozone layer, with the effect of further depressing plant growth.

Moreover, there would be many interactions among these environmental "insults", leading to a pervasive phenomenon of synergisms. That is to say, the insults would tend to compound each other, until the overall impact would be greater than the sum of the individual components. These synergisms are difficult to discern ahead of time (and the likely consequences of nuclear war are not amenable to experimental testing). But we know enough about synergisms in general to predict that their effects would be adverse indeed (see examples below). In addition, the

environmental assaults listed are no more than the ones we can anticipate. Completely unexpected ecological reactions would surely occur, since this would be the greatest environmental upheaval that the Earth has experienced in millions of years--far more disruptive than any ice age.

Prospect for British Agriculture

How would agriculture fare in this country? Let us look at the prospect from three salient standpoints.

(a) Die-Off of Crops

Crops would suffer principally through the steep drop in temperature--to 15-20 degrees C. below normal levels for Britain, possibly less and possibly much more. The impact of reduced temperature on plants depends on three factors: the season when it strikes, the length of time it persists, and the built-in capacity of plants to tolerate cold. Winter wheat, one of our most cold-resistant crops, endures temperatures as low as -20 degrees C., i.e. some 25 degrees C. below typical daytime temperatures of a British winter--provided it has had at least six weeks to develop its full "hardiness." But it is killed by a sudden decline of only 10 degrees C. during its September-October hardening phase, while a sudden frost, however mild and brief, during its active-growth phase of spring and summer is similarly lethal. In common with virtually all temperate-zone plants, modern crops cannot harden at all when once they have started on their growing season, even if a temperature decline arrives only gradually. By contrast, the nuclear winter scenario postulates a sudden arrival of acute cold--which then persists night and day for months at a stretch.

So if a nuclear winter were to overtake wheat during its more tolerant phase of late autumn and winter, the overall severity of this unprecedented phenomenon would leave the crop with only moderate prospect of survival. When we consider further adverse effects (such as suspended photosynthesis, chemical contaminants, and ionizing/UVB radiation), with their synergistic compounding of impacts, it is difficult to see how the crop would have much chance of survival. If a war were to break out during the sensitive phase of spring and summer, the crop would be eliminated immediately.

As for other crops, oats can tolerate maximum cold of -10 degrees C., barley -14 degrees C. and rye -30 degrees C. by mid-October, provided the plants have had time to adapt. But none of them withstands cold much below 0 degrees C. after the onset of the spring growing season. Similarly cabbage, while tolerating winter temperatures as low as -10 degrees C., cannot survive a late spring frost of only -1 degree C. Not unexpectedly, crops of warmer temperate lands, such as maize and soyabeans, react adversely to unseasonal cold even though the temperature remains

well above freezing point. Tropical plants, such as rice and sorghum, are still more sensitive.

So much for herbaceous plants. Now for trees. Deciduous species cannot withstand even slight and transient frosts after they have begun their active growth. Evergreen trees, including those of alpine regions which endure temperatures as low as -50 degrees C. in mid-winter, are killed by temperatures only a few degrees below zero in summer.

In short, it is not only the magnitude of temperature declines that count in a nuclear-winter scenario. It is their ultra-abrupt start, followed by their drawn-out and unremitting impact.

Let us remember, moreover, that the outcome described here would stem from a relatively limited war of only 5000 megatons. In certain circumstances, such as an attack directed solely at cities, a nuclear winter could be brought on by a war of only 100 megatons (much less than Britain's arsenal). So the conclusions are distinctly conservative.

On top of the cold factor, a nuclear winter would impose further stresses on crop plants. It would severely disrupt, if not terminate, photosynthesis, with all the traumas that would entail. Air pollutants such as pyrotoxins and acid rain would leave plants diseased and damaged to a degree that would grossly reduce their capacity to sustain a nuclear winter. And the same with ionizing radiation: several crops, notably barley, rye, oats, maize, beans and peas, sugarbeets and tomatoes are unusually sensitive to radiation, while trees, and especially evergreen trees, are very vulnerable. The plants that can best withstand radiation are certain forms of ground cover, such as small shrubs and grasses.

In the wake of a nuclear winter, then, many British landscapes would lose so much vegetation that they would look more like sub-Arctic environments.

Let us bear in mind too that the great majority of our leading crops, being annuals, are basically dependent on additives from farmers in the form of fertilizers, herbicides and the like. In the aftermath of a nuclear war plus a nuclear winter, there would be no fertilizers, no fungicides and herbicides, no pesticides, no fuel for tractors and other machinery, indeed none of the supports of agro-technology and social organization that underpin modern agriculture.

(b) Outbreak of Pests

The animal forms that would probably prove best able to survive a nuclear winter are small-bodied insects--these also being the ones that are most resistant to radiation. After the

nuclear winter receded, certain species would start to thrive until their numbers reach pest proportions. Conversely, the natural enemies that usually keep insect pests under control, viz. predators and parasites, would be less likely to survive a nuclear winter by virtue of their smaller numbers and ecological specializations. As a result, there would be a proliferation of aphids, weevils, wire worms, eel worms, leather jackets, and other established pests, together with many pests of novel types. Similarly, it is all too likely that "opportunistic" plant species, i.e. those that flourish in disrupted environments, would spread. Result, existing weeds would expand, joined by many new weeds.

All in all, agro-environments of a post-nuclear world could well feature a "pest and weed ecology."

(c) Outlook for Livestock

As for domestic livestock, it is difficult to imagine that many creatures could survive a nuclear winter at all. They would have next to no protection against cold, since farmers, trying to keep alive in deep-underground bunkers, would not be able to tend them in sheds that normally offer shelter during winter. Nor would there be any fuel to heat the sheds. Feedstuffs would not be available, while pasture food would generally be scarce or contaminated. Surface water would be frozen to a depth of at least one metre. When the nuclear winter faded away, such animals as have survived would suffer UVB damage to the cornea, and without sight, animals and birds--whether cattle and chickens, or rabbits and sparrows--could not survive beyond a week or two at most.

The "Ocean Effect"

In theory, there could be some hope that Britain would not suffer the full rigours of a nuclear winter because of the thermal reservoir of the surrounding seas and its capacity to moderate falls in temperature. But in practice, there could well be qualitative as well as quantitative changes for the climate of the northwestern Europe seaboard. Britain would then become subjected to bitterly cold winds from the north and northeast, unusually powerful and persistent. These winds would thus counter the "ocean effect," and would leave Britain's nuclear-winter climate rather more akin to the harsh conditions of continental interiors.

Nor would the sea serve as a source of food to British survivors. Phytoplankton, viz. primary producers at the base of marine food-chains, would have been depleted through their sensitivity to low light levels, with shatter effects throughout marine ecosystems. Zooplankton would have suffered through UVB radiation. Thus there would be few fish to catch. In any case, they would be contaminated with radionuclides. Moreover gale-

force winds would cause prolonged storms along coastlines. Ports and shipping would have been destroyed through "carpet bombing" of adjacent seas as part of the anti-submarine strategy.

A Hunter-Gatherer Lifestyle?

All in all, those British communities that come through a nuclear attack and the subsequent nuclear winter--surely far fewer than the 10-15 million postulated by civil defence planners--would find all too little to eat. It is difficult to see how conventional food stocks of any sort would be available, while foreign imports would be cut off. Due to environmental degradation and its destruction of our agricultural resource base, the critical phase for survivors would extend not only during the nuclear winter itself, but for a lengthy period afterwards. Were a war to break out in spring or summer, the nuclear winter would be followed by a normal winter (as part of the season-by-season cycle). A war in autumn or winter would mean there would be three winters in a row. Far from being able to resurrect farming forthwith, even in rudimentary form, survivors would have to make out off the products of natural ecosystems--precisely at a time when these ecosystems would have been impoverished almost beyond recognition.

So survivors would have to try their hands at a hunter-gatherer lifestyle, supposing there were anything to be hunted and gathered beyond insects and acorns. Widescale starvation would surely be the outcome--and not just in the immediate aftermath but during the following year at least, indeed until such time as bare subsistence crops could be established.

Synergisms

The principal preoccupation of a post-war world, viz. the restoration of agriculture, would be influenced by numerous synergisms. As we have noted, we should not consider the various categories of environmental assaults in isolation from each other. Rather we should consider how their interactive and cumulative effects would tend to aggravate one another. We have already seen that crop plants, weakened from the outset by ionizing radiation and chemical contaminants, would suffer months-long assault from acute cold and litle light, and would finally receive heavy doses of UVB radiation for years on end. The mutually-reinforcing consequences of these impacts would amplify their separate effects. As a result, there would be major stresses on the immune systems of plants, leaving them all the more vulnerable to diseases, notably to pathogens. At the same time, high ambient radiation fluxes would generate mutations, leading to new varieties of pathogens.

A further set of synergisms would arise, this time with respect to soil. Soil fertility depends on micro-organisms that play a key role in cycling nutrients. Yet pyrotoxins and other

chemical pollutants would deplete nitrogen-fixing organisms, mycorrhizal fungi and decomposers, among other micro-organisms that serve as essential elements of agro-ecosystems. At the same time, the die-off of vegetation would leave soil vulnerable to erosion by winds--precisely at a time when strong winds would be blowing for months. On top of all this, weather patterns would probably remain unstable for years, due to climatic instability. There could be, for example, an increase in "albedo", viz. the reflectivity of the Earth's surface, this being a prime factor in wind currents and rainfall patterns. There would probably be a super-fast buildup of carbon dioxide, leading to a greenhouse effect with other dislocations of climate mechanisms. The results would include unexpected floods and droughts, causing further damage to soils.

Any of these factors on its own would make the restoration of agriculture difficult. Taken together, they would grossly exacerbate the situation. All this would occur, moreover, at a time when there would be no supports such as energy, pesticides, fertilizer, seedstocks, etc., that make modern agriculture possible. It is realistic to suppose, then, that organized agriculture could not be re-established for years, if not decades.

Policy Implications

A nuclear winter would affect any nation susceptible to the climatic dislocations, i.e. all nations throughout the northern hemisphere, combatant and bystander nations alike. It would apply equally to any nation that attempted a pre-emptive first strike--even if the strike were to prove so successful that it eliminated all retaliatory capacity on the part of the adversary. The so-called victor would suffer from the nuclear winter just as much as would the vanquished. In other words, a nuclear strike must, be definition, prove suicidal. A nuclear solution is no solution of any sort.

Conclusion

In a recent paper published in the leading American journal Science (December 23rd 1983), prepared by 21 biologists and ecologists from around the world, the summary finding reads as follows: "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 civilization 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."

Bottom-line question: how long before a nuclear winter could be followed by a spring of any sort?

15th March 1984

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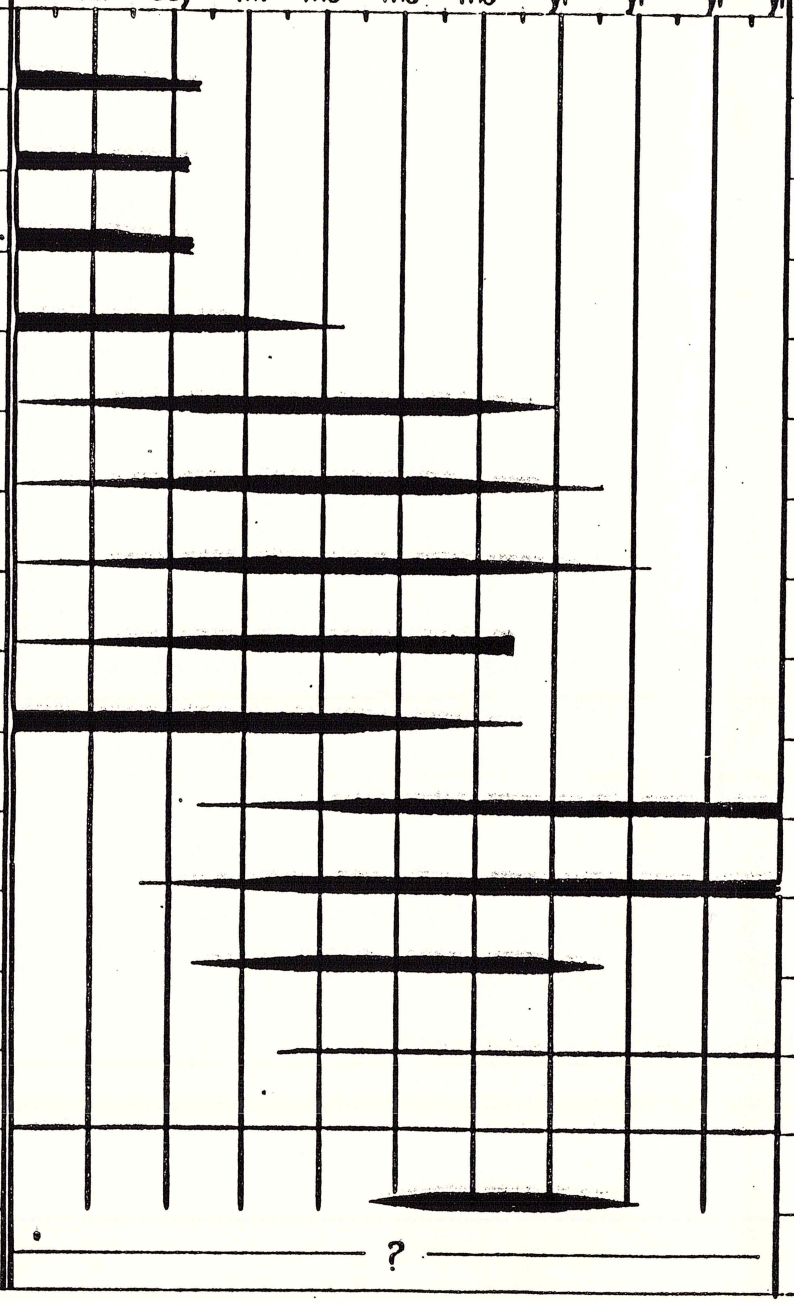
SCHEMATIC SUMMARY OF BIOLOGICAL EFFECTS OF THE BASELINE (5000 MEGATONS) NUCLEAR WAR



Effect	U.S. / S.U. Population at risk	N.H. Population at risk	S.H. Population at risk	Casualty rate for those at risk	Potential global death
Blast	H	M	L	H	M - H
Thermal Radiation	M	M	L	M	M - H
Prompt Ionizing Radiation	L	L	L	H	L - M
Fires	M	M	L	M	M
Toxic Gases	H	M	L	L	L
Dark	H	H	M	L	L
Cold	H	H	H	H	M - H
Frozen Water Supplies	H	H	M	M	M
Fallout Ionizing Radiation	H	H	L - M	M	M - H
Food Shortages	H	H	H	H	H
Medical System Collapse	H	H	M	M	M
Contagious Diseases	M	M	L	H	M
Epidemics and Pandemics	H	H	M	M	M
Psychiatric Diseases	H	H	L	L	L - M
Increased Surface Ultraviolet Light	H	H	M	L	L
Synergisms	?	?	?	?	?

Table 1

Temperature resistance of the leaves of vascular plants from different climate regions. Limiting temperatures are for 50% injury (TL_{50}) after exposure to cold for 2 h or more, or after exposure to heat for 0.5 h. The data were taken from many original publications. Sources are given by Altman and Dittmer (1973), Biebl (1962), Larcher (1973a), Larcher and Bauer (1980), and Kappen (1980).

Plants	°C for Cold Injury in the Hardened State
Tropics	
Trees	+ 5 to -2
Forest undergrowth	+5 to -2
Mountain plants	-5 to -10
Subtropics	
Sclerophyllous woody plants	-8 to -12
Subtropical palms	-5 to -14
Succulents	-5 to -10
C_4 grasses	-1 to -3 (-8)
Temperate zone	
Evergreen woody plants of coastal regions with mild winters	-6 to -15 (-25)
Arcto-tertiary relict trees	-10 to -25 (-15 to -30)[a]
Dwarf shrubs of Atlantic heaths	-20 to -30
Winter-deciduous trees and widely distributed shrubs	(-25 to -40)[a]
Herbs	
Sunny habitats	-10 to -20 (-30)
Shady habitats	
Water plants	ca. -10
Cold-winter areas	
Evergreen conifers	-40 to -90
Boreal broad-leaved trees	(-196)[a]
Arctic and alpine dwarf shrubs	-30 to -70
Herbs of the high mountains and arctic	(-30 to -196)[a]

[a] Vegetative buds.

U.S.

Table 2

Current Production of Various Crops and Animal Products and Projected Production for the Year After the Nuclear War
(million metric tonnes)

	Current Production*	Projected Production	
		Winter War	Summer War
Meat Products	28	10	5
Dairy Products	32	10	5
Eggs	4	0	0
Grains	307	20	0
Vegetables	32	3	0
Fruits	17	2	0
Sugar	14	0	0
TOTAL	434	45	10

*USDA, 1981.