FARMING AND THE NUCLEAR WINTER

PROCEEDINGS OF
A CONFERENCE, SPONSORED
BY THE

D R T
DEFENCE RESEARCH TRUST

at

Dryburgh Abbey Hotel
Newtown St. Boswells

on

SATURDAY, 13th OCTOBER, 1984

This conference was organised by a group of local scientists and doctors in order to allow Scottish farmers, planners and others interested to hear about and discuss the new scientific findings predicting global climatic disruption following nuclear war and the impact of these changes on agriculture.

THE SCOTTISH NUCLEAR WINTER CONFERENCE

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CONTENTS

INTRODUCTION

This booklet consists essentially of the proceedings of the Scottish "Farming and the Nuclear Winter" Conference, held on October 13th, 1984 at the Dryburgh Abbey Hotel, near Newtown St. Boswells in the Borders Region. The chief purpose of both the conference and this publication is the same: to inform farmers, planners and others concerned with the countryside about the new predictions of serious disturbance to the Earth's climate that could be triggered by nuclear war.

These effects, known as the nuclear winter, had only been recognised for a year when the conference was held, but their world-wide scale and far-reaching implications had already jerked the scientific community out of complacency. Although further research was certainly needed, it was already clear that there was a general threat to agriculture and food supplies throughout Scotland, which extended to cover most of the Northern Hemisphere, and perhaps the whole world.

In these circumstances, it was clearly important to explain to farmers that in addition to the direct effects of nuclear explosions, which are relatively well known, there could be unprecedented environmental consequences that would dislocate Man's activities and Nature's productivity. We appear to be risking severe damage to the very life-support systems, such as the flow of light and heat from the Sun, which permit our agriculture and thus our civilisations to flourish. Farmers, as custodians of the land, are in a special position to understand this, and to discuss its implications through their organisations, and so the presence of representatives of the National Farmers' Union of Scotland at the conference was particularly welcome.

There are five contributors to the proceedings. Dr Kelly outlines the nature of the nuclear winter, and the probable situation of the United Kingdom. He also describes both the uncertainties in the predictions, and the general agreement with them given by national and international scientific organisations. Dr Longman explains some of the implications for crop plants of large reductions in sunlight and sharp drops in average temperatures, giving details of preliminary experimental tests on cereal yields. Dr Crossley covers the impact of nuclear war on British agriculture, including direct and indirect damage to crops, livestock, supplies and infrastructure, but excluding the nuclear winter. And Mr Butler translates the scientists' warnings into the actual situation which he as a farmer might have to face. He describes the attempts by a group of Devon farmers to get good information on what difficulties to expect, and how to try to cope with them.

At the time of the conference, the official document "Home Defence and the Farmer" had been out of print for more than 20 years. In replies to parliamentary questions in the Commons and the Lords, the government made it clear that it would await the findings of the international SCOPE enquiry ("Scientific Committee on Problems of the Environment") before drawing any conclusions about the nuclear winter. It was therefore surprising to find that a new booklet, "Civil Defence and the Farmer", devoid of information on this subject, was quietly issued shortly before the conclusions of the SCOPE Report were due to be released.

The SCOPE enquiry into the Environmental Consequences of Nuclear War was carried out under the auspices of the International Council of Scientific Unions, which acts on behalf of the major scientific organisations of more than 70 countries. The members of the Steering Committee, under the Chairmanship of Sir Frederick Warner, FRS at the University of Essex, report that:

> "as representatives of the world scientific community drawn together in this study, we conclude that many of the serious global environmental effects are sufficiently probable to require widespread concern. Because of the possibility of a tragedy of an unprecedented dimension, any disposition to minimise or ignore the widespread environmental effects of a nuclear war would be a fundamental disservice to the future of global civilisation."

This booklet contains a critique of "Civil Defence and the Farmer", and also a list of sources of information, including the widely praised publication, "Guide to the Effects of a Nuclear Disaster on Agriculture", written by the Devon farmers' group. So that it should not be wholly devoted to these grim and depressing topics, the fifth paper by Dr Woolfson takes up the controversial question of alternatives. There may be ways in which Britain could be defended which might in time allow us to reduce our dependence on the nuclear arsenals that are too dangerous to use. In essence, we have the choice of developing certain of the very effective but less provocative of the emerging conventional military technologies into what a BBC television programme called "Defensive Defence", instead of adding yet more threatening space-age weapons to the existing forces.

It is also reassuring that some of the largest and most sophisticated modern computers were available to perform the very complex and comprehensive calculations which have allowed us to comprehend in advance what nuclear war would mean. In the words of Russell W. Peterson, Chairman of the US Center on the Consequences of Nuclear War, "None of us can responsibly sit back today and let somebody else worry about this problem".

16th October, 1985.

WHAT IS THE EVIDENCE FOR THE NUCLEAR WINTER?

P.M. Kelly

No-one needs to be reminded that the explosion of even a small number of nuclear weapons would result in massive loss of life and devastation. It is, however, only in recent years that the possibility of long-term implications for the Earth's weather and climate has been recognised. It had been thought that the major atmospheric consequence would be an increase in the amount of harmful ultraviolet radiation reaching the Earth's surface because of the chemical products of the nuclear explosions. But the scale of the atmospheric pollution had been underestimated.

The extent of the pollution resulting from a nuclear exchange was first assessed in detail by the atmospheric scientists Paul Crutzen and John Birks in 1982, in a special issue of the Swedish Journal <u>Ambio</u> devoted to studies of the aftermath of a nuclear war. Since then, the climatic and biological effects of the cloud of pollution have been studied by a number of investigators, and a summary of the pioneering work has been published recently (Ehrlich et al., 1984).

During a nuclear exchange, dust would be thrown high into the atmosphere by the blast of the explosions. Vast clouds of smoke are likely to result from fires at military bases, in cities, in industrial areas, and in forests. These fires would burn for days, and possibly weeks, and in the early stages firestorms could spread the smoke high into the air. Close to half the planet might be shrouded by a pall of dust and smoke, producing twilight at the Earth's surface. This nuclear cloud could result in a drop in temperature on a scale that has not been experienced since the last Ice Age. For a period of weeks, maybe months, temperatures might remain at or below freezing over much of the northern land masses - this has become known as <u>the nuclear winter</u>.

Predicting the effects of an event as awesome and unthinkable as nuclear war stretches to the limit our understanding of what causes weather and climate. The purpose of this summary is:

(a) to present the main points of the nuclear winter research;

(b) to identify the uncertainties that are inevitably involved; and

(c) to extract a picture of the nuclear winter as it might be experienced in the United Kingdom.

The research that I am about to describe carries with it tremendous social responsibility - we are discussing the possible devastation of at least half of our planet - and I shall end by describing the responses of various scientists, and groups of scientists, to the results of these studies.

THE NUCLEAR CLOUD

Estimation of the effects on weather and climate of the nuclear cloud of dust and smoke is a complex process involving a wide range of scientific disciplines, and many uncertainties.

The analysis begins in the realm of war games. How many and what type of weapons might be used in a nuclear war? What kind of targets are likely - military, industrial, civilian? How long could a nuclear war last? This stage of the study has to be undertaken on a "what if?" basis, second-guessing the military strategists. Strategically plausible scenarios are developed covering exchanges ranging from a relatively limited attack on, say, a handful of cities, to the detonation of most of the world arsenal in a fit of mutual assured destruction.

I shall be discussing the effects of one of the more likely scenarios - an exchange of around 5000 Megatons (Mt). To place this in context, the world arsenal at present includes about 12,000 Mt of strategic weapons, equivalent in destructive power to about 300,000 Hiroshima bombs. Both the United States and the Soviet Union can destroy each other's cities fifty times over.

Next, the characteristics of the cloud of pollution associated with each scenario have to be determined. Estimates of the amount of material that may burn and produce smoke at military bases, in cities, and in industrial and rural areas are made. Smoke production at targeted sites is then assessed and the quantity of dust generated by groundbursts on and airbursts over these targets is calculated. The result is an estimate of the total amount of material injected into the atmosphere, and some idea of its physical properties.

The components of the cloud are:

(a) Dust blasted up from the ground by the explosions. This consists of fine, relatively bright particles which scatter the heat and light from the Sun, diverting some of it before it can reach the ground.

(b) Soot or smoke arising from the many fires ignited by the blasts. This black, oily soot is very effective at absorbing and trapping the Sun's heat high in the atmosphere. It is the smoke which is responsible for the major part of the cooling. It stops the Sun's heat from reaching the ground but allows any remaining warmth at the Earth's surface to escape to space relatively unhindered.

(c) Chemical products of the nuclear reactions and fires. These could result in substantial acid rain and, when sufficient sunlight becomes available, photochemical smog. Large quantities of toxic gases and substances will be released. In the high atmosphere, ozone levels may be reduced, allowing harmful ultraviolet radiation to reach the Earth's surface.

Inevitably, there are many areas of uncertainty in these initial stages of the analysis. Can we really know how a nuclear war might be fought? How much can we say about the physical nature of military targets? How good is our knowledge of the physics of smoke production in large-scale fires? How will the cloud spread up through the atmosphere and around the world? How fast will it be washed out by rainfall?

THE NUCLEAR WINTER

The next stage in the analysis is to estimate the overall effect of the nuclear cloud on our weather and climate. I shall as an example use the results of the pioneering American TTAPS group - Turco, Toon, Ackerman, Pollack and Sagan (1983). The TTAPS group first used a computer model to work out how much of the Sun's heat and light would be intercepted by the cloud before reaching the Earth's surface. In the case of the 5000 Mt nuclear exchange, a reduction of over 95% in the net amount of solar energy reaching ground level is predicted for the first two to three weeks after such a war and the reduction remains substantial over the first two to three months. For much of the time, the Sun would be visible only through patches in the nuclear cloud. There would be semi-permanent twilight, and at light levels as low as this photosynthesis would be greatly reduced.

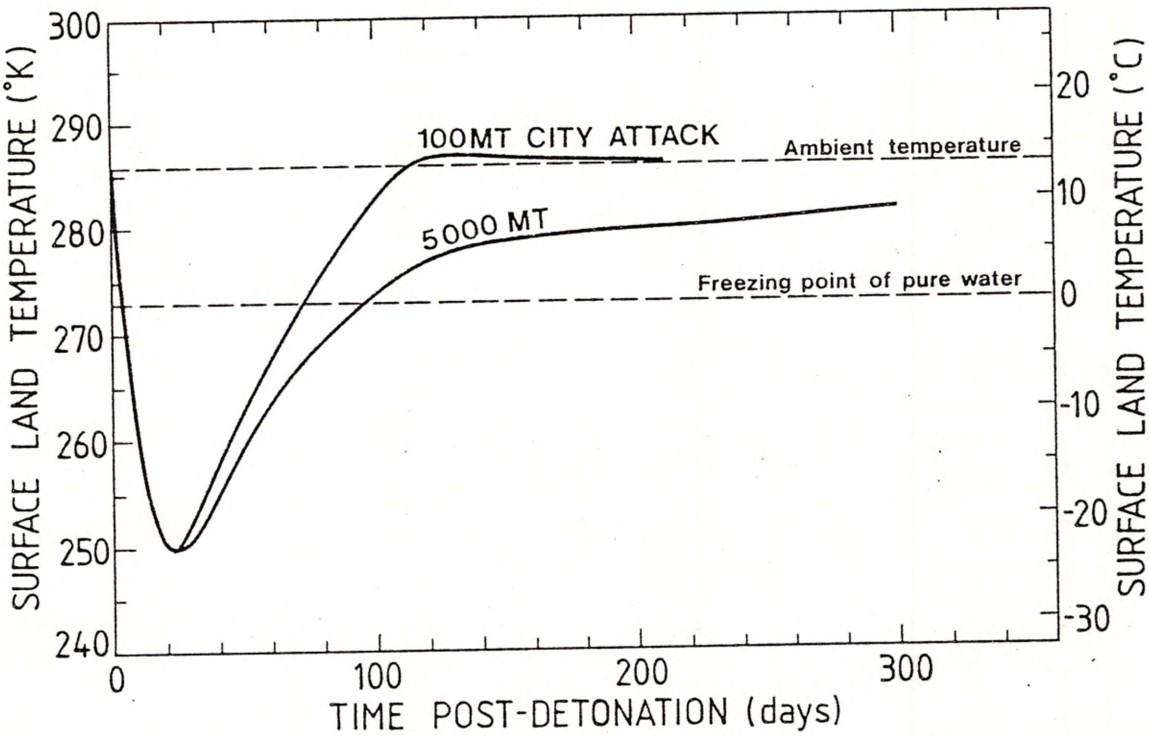

Figure 1

Change in surface air temperature in the continental interiors of the Northern Hemisphere for two exchange scenarios. Temperature change is plotted along the vertical axis and time, in days, along the horizontal axis. The upper horizontal line indicates present-day annual average temperature.

In both cases, a pronounced drop in temperature occurs in the initial period after the nuclear exchange. Temperatures remain below freezing for some months and only approach present-day conditions towards the end of the first year. The 100 Mt attack consists of many warheads targeted on a large number of cities and has the same initial effect as the 5000 Mt exchange because the amount of smoke generated is not very different in these two cases. Cities contain a large amount of combustible material, and they can burn once only.

After Turco et al. (1983).

The TTAPS group then used another computer model to predict the effects on the temperature of the atmosphere. Simulations for two of the scenarios studied by the TTAPs group are shown in Figure 1. In the case of the 5000 Mt exchange, surface temperatures drop by about 35 degrees Centigrade in the first month and remain below freezing for around three months. A change in temperature of this magnitude and rapidity is without parallel in recent centuries.

These estimates are for the continental interiors of Europe, Asia and North America. The temperature drop over the oceans would be less than over land as the oceans take longer to cool down. Here the TTAPS model predicts a fall in temperature of only a few degrees. As we shall see, this may afford some protection for the United Kingdom when the winds blow off the sea.

How long would the nuclear winter last - weeks, months or years? By the end of the first year, it is likely that most of the nuclear cloud will have fallen to the ground or will have been washed out of the air by rain or snow. But part of the cloud would remain high in the atmosphere, above the rain and snow, for a couple of years at least, prolonging the nuclear winter. Moreover, the Earth's snow and ice fields and oceans, adjusting to the dramatic drop in the temperature of the overlying air, would have altered and these effects could extend the cooling into year two, and possibly year three. Temperature drops would be nowhere near as great as during the first year but they still could be significant.

OTHER MODELLING STUDIES

The TTAPS results that I have just described have now been reproduced in a number of other studies, for example:

(a) by Mike MacCracken (1983) at the Lawrence Livermore National Laboratory in California;

(b) by Curt Covey and colleagues (1984) at the National Center for Atmospheric Research in Boulder, Colorado;

(c) by Alan Robock (1984) at the University of Maryland; and

(d) by Vladimir Alexandrov (1983) at the Computing Centre of the Soviet Academy of Sciences in Moscow.

The consensus that emerges from these studies, when due allowance is made for differences in experimental design, is that, on average, a net cooling of around 15 to 20 degrees Centigrade would occur over the land under the nuclear cloud.

These studies do not provide truly independent tests of the original TTAPS results. Although the computer models used vary in their formulation and degree of sophistication, they are all based on the same understanding of the climate system. They contain numerous simplifications and approximations and were designed to simulate present-day conditions rather than the radically different climatic state of the nuclear winter. All the investigators assumed a similar nuclear cloud to facilitate comparison of results though it is encouraging that they turned out to be very close in their predictions.

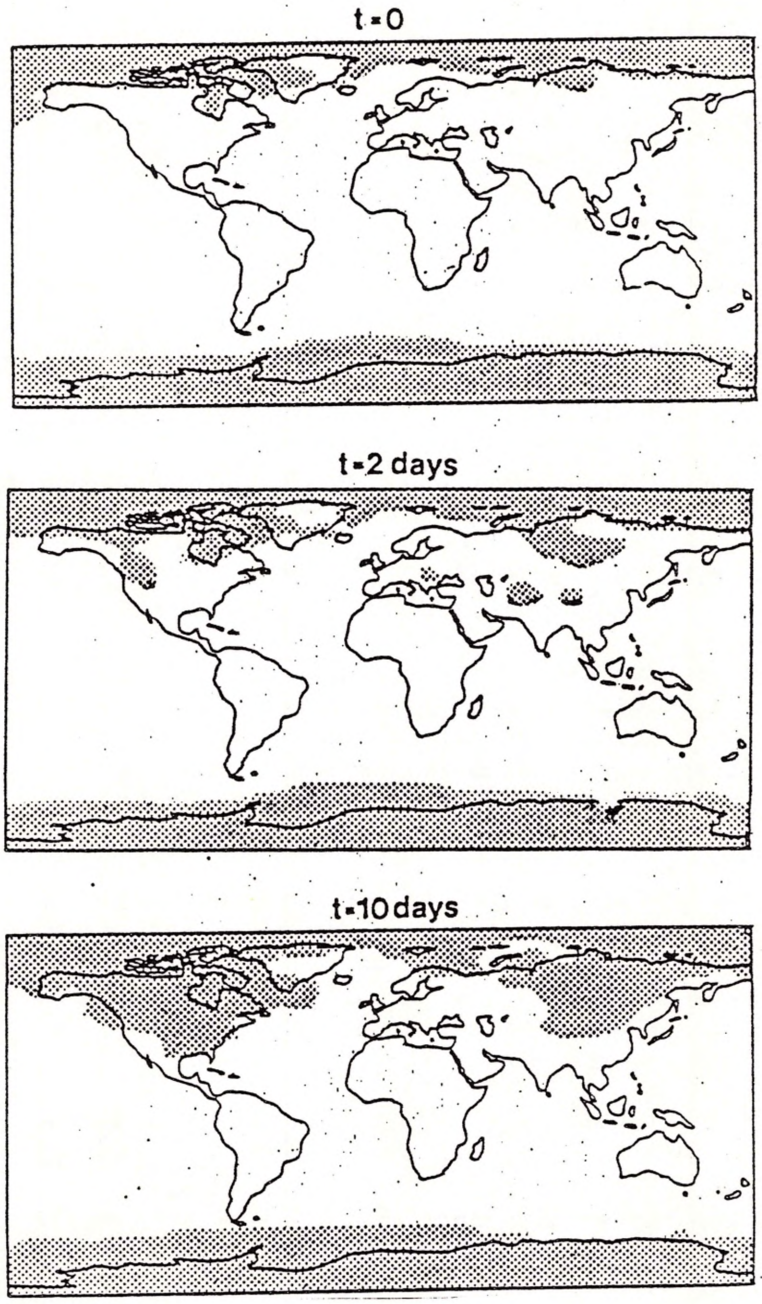

Figure 2

The initial development of the nuclear winter simulated by a computer model for day 0, before the exchange, for day 2, and for day 10. The shaded areas indicate temperatures below freezing. These results are for a summer war; the cooling is likely to be less if the exchange occurred at other seasons.

The sequence shows the advance of freezing conditions from polar regions with the oceans affording some protection to the neighbouring landmasses. This protection is critically dependent on the direction of the prevailing winds.

After Covey et al. (1984).

Each study has resulted in information about different aspects of the nuclear winter. For example, Curt Covey and his colleagues produced maps showing how the cooling might affect different parts of the world in the days immediately after a nuclear exchange. The initial development of the nuclear winter simulated by their model,is shown in Figure 2 for day 0, before the war, day 2 and day 10. These results are for a summer war, and the shaded areas indicate temperatures below freezing. The sequence shows the advance of freezing temperatures from polar regions with the oceans affording some protection to the neighbouring landmasses. Despite this protection, and the fact that this is a summer simulation, by day 10 temperatures have dropped to close to freezing in the United Kingdom.

Covey and his colleagues also noted that the atmospheric circulation might change and blow part of the cloud into the Southern Hemisphere, spreading the cooling across the Equator. A similar result was produced by the Soviet model. Climate does not respect neutrality!

These models are experimental and there is a clear need for further research in this area. The results cannot be taken as predictions in the sense that tomorrow's weather can be forecast by computer. They provide, at best, an indication of what might happen. And, by the nature of the problem, the crucial process of testing theories and model results in the real world is ruled out. It is, however, possible to obtain some idea of how well computer models perform, and to improve understanding of the physical processes involved, by study of past events that are similar in some respect to a nuclear catastrophe. Such analogues include dust storms (on Earth or Mars), forest fires, fires induced by conventional bombing (for example in Dresden and Hamburg) and by the atomic devastation of Hiroshima and Nagasaki; as well as meteorite or asteroid impacts, and volcanic eruptions.

As the low-level cloud of dust from the eruption of Mount St. Helens in Washington State in May 1980 swept across the United States, it produced day-time cooling of up to 8 degrees Centigrade (Robock and Mass, 1982). The dust and gas thrown high into the atmosphere by major eruptions, such as Krakatau in 1883, can cause large-scale cooling of up to 1 degree Centigrade for some months, and the effects may still be observable years later (Kelly and Sear, 1984).

EFFECTS ON THE UNITED KINGDOM

How might the United Kingdom experience the nuclear winter? Let us consider one possibility. An average temperature drop could occur over the northern middle latitude landmasses of some 15 to 20 degrees Centigrade, with temperatures reduced by up to 35 degrees in some continental regions but by only a few degrees over the central oceans. Situated between ocean and continental landmass, the United Kingdom is likely to experience an average temperature decrease of somewhere between 10 and 20 degrees Centigrade. The range from day to day is likely to be great, between 5 and 35 degrees below normal values depending on whether the wind blows from the cold continental interior or off the relatively warm ocean. There is reason to believe that winds off the continent will be much more frequent than they are now.

Whatever season the nuclear exchange should occur in, average temperatures will drop to freezing or below. It is likely that weather conditions will be more severe than a harsh winter in the present day. In the case of a summer war, the closest parallel (in magnitude though not in duration) is the drop in temperature experienced over western Europe at the height of the last Ice Age.

What will we find as we emerge from under the kitchen table, pushing aside the sandbags?

Darkness. Twilight, day-long, with only an occasional glimpse of the Sun. Temperatures swinging from day to day between above-freezing and perhaps 20 or so degrees below. Intense storms due to the temperature contrast between the cold land and the relatively warm ocean. Thunderstorms and black rain. Dense fogs in coastal areas as the oceans pump moisture into the surface layers of the atmosphere. The ground permanently covered by frost and snow. All surface water frozen.

Human survival is possible in such conditions, with adequate protection. Without Arctic survival gear, and in a physically and psychologically shattered state, survival at sub-zero temperatures is likely to prove difficult, to say the least. People, domestic crops and animals, and wildlife will be subject to severe stress from radiation poisoning and pollution of the land and air, lack of light, low temperatures and other forms of climate hazard and, as the nuclear cloud clears, increased ultraviolet radiation (Ehrlich et al, 1983).

THE RESPONSE OF THE SCIENTIFIC COMMUNITY

How seriously do atmospheric scientists take these results? How do they see the wider, political implications of the findings?

On an individual level, the nuclear winter debate has, to date, been conducted in an extremely responsible fashion. Results have been reported with scrupulous honesty and criticism has, for the most part, been informed and offered constructively. The importance of public debate of the nuclear winter findings and their implications has been recognised by many of the scientists involved in the research. Leading American and Soviet scientists toured the United Kingdom in autumn 1984 describing their results at a series of public meetings.

On a more formal level, in September 1983, the Council of the prestigious American Meteorological Society called on the nations of the world to take whatever measures are necessary, such as the adoption of appropriate treaties, to prevent the use of nuclear weapons and to avoid nuclear war. In early 1984, the Danish Meteorological Society reprinted this statement on the front cover of its journal and, noting that "far too many scientists shut themselves up in their ivory towers", commented that "it is... gratifying that such a large and influential group of meteorologists... clearly supports a peaceful solution to one of the greatest problems of our time".

Yuri Izrael, a Corresponding Member of the Soviet Academy of Sciences, Chairman of the Soviet Committee for Environmental Control and a renowned atmospheric scientist, writing in one of the leading Soviet journals about the ecological consequences of nuclear war, concludes that...

> "The issue is that of life on Earth itself. Aggression, leading to the unleashing of nuclear war, is an absolute crime against humanity and the whole biosphere of the Earth" (Israel 1983).

Carl Sagan, a member of the TTAPS group, has published a detailed consideration of the policy implications of the nuclear winter in the journal Foreign Affairs (Sagan 1983/84). He claims, perhaps optimistically, that a threshold (defined in terms of the number of warheads exploded and targeting policy) can be determined, below which the nuclear winter effect is unlikely to be triggered. He goes on to suggest that arms limitation talks should strive for "build-down" at least to this level, which he estimates was exceeded during the 1950s. Sagan points out that the findings have major implications for the first strike or counterforce strategies which are undermining the strategy of deterrence and mutual assured destruction. Even in the unlikely event of a successful first strike, there could be no winner in the nuclear winter. The victor might well suffer as much as the vanquished.

Under pressure from groups such as the Natural Resources Defense Council in Washington DC, the United States government has moved to consider these implications. Richard L. Wagner, assistant to Defense Secretary Caspar Weinberger, testified before a Congressional committee in July 1984 that "even a small possibility of... catastrophic effects must be considered very seriously". Plans have been announced for a $50 million 5-year research project.

The National Academy of Sciences, based in Washington DC, has recently reviewed the nuclear winter research at the request of the Pentagon and has concluded that, despite the uncertainties and an obvious need for further investigation, there is a genuine possibility of climatic catastrophe following a nuclear exchange. The details of current estimates may be in error, limited exchanges may not trigger the effect, but the danger cannot be denied.

To date, there has been little serious consideration of the implications of the nuclear winter for civil defence and long-term survival in the aftermath of a nuclear war. I hope that this meeting marks a step in that direction. While some may say that discussion of the implications of the nuclear winter findings should await the results of further research and clarification of various uncertainties, this seems to me to be a rather irresponsible attitude. The risk has been convincingly demonstrated. Given what is at stake, how long can we afford to wait?

ACKNOWLEDGEMENT

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HOW WELL COULD CROPS AND TREES SURVIVE THE NUCLEAR WINTER?

Alan Longman

Here in the heart of the Scottish countryside it is very difficult to imagine that nuclear war could happen. Perhaps it is easier to feel that if it did then maybe we would escape the direct effects, and that somehow we'd be able to manage. However, in Threads and On the 8th Day, shown by BBC 2 on 23 and 24 September 1984, we were given a glimpse of what it might really be like. What I want to examine now are the likely effects of nuclear winter on the production of food and materials essential to survival in the longer term.

A few months ago, a colleague from the East of Scotland College of Agriculture, who was giving a talk at the Bush Estate near Edinburgh, said that he thought that scientists should be able to shout when they saw something dangerous coming up. That sums up what the scientists at this conference are trying to do - to give a warning shout about a threat which we are only just beginning to grasp, but which we can see is extremely large. Were we telling you for instance about a new variety of crop plant, we could probably inform you that it had been tested over years, and tried out in many different farming situations. In the case of the nuclear winter we can't do this, but we are saying that we have stumbled on something new which had previously been overlooked, that it's clearly important and that we think you ought to know about it.

Although nuclear winter could affect farming in several ways, I want to concentrate on light and temperature, two basic factors governing the growth and production of crops and trees. To a biologist, the sustained reduction in light levels is perhaps the most disturbing thought. All natural and agricultural ecosystems, and indeed the marine and freshwater systems upon which fishing is based, depend on sunlight. Through their photosynthesis, green plants produce the sugars that provide the food supply, not only for themselves, but for all animals including humans, and also for most of the micro-organisms in the soil that break down and re-cycle nutrients. So the ecosystem as we now understand it in biological terms is a cycling structure of energy and materials, and in fact of things like genetic information as well.

What would happen if sunlight levels were substantially reduced for periods of a few weeks or months? I have been doing some preliminary trials on cereals, in which I have specifically avoided the approach of exposing the same batch of plants to frost, low light, radiation and other stresses. I isolated one factor - the light - and subjected similar large pots of cereals to dim light for periods varying from 1-6 weeks, before returning them to normal lighting. The dim light regime provided about 1% of the level that saturates photosynthesis in wheat, and was given at normal temperatures. Control sets were maintained throughout under full light.

Spring barley plants given dim light when two weeks old were seen, by means of the time-lapse photography used in On the 8th Day, to fall over after 1-2 weeks. Nevertheless, most plants remained alive, apparently resembling the winter varieties which regularly withstand low light levels early in the life-cycle. Yields could however be expected to be delayed, and smaller than usual, due to light restriction when young.

At 6 weeks old, spring wheat plants were at peak vegetative growth, and even one week of dim light at this stage caused temporary yellowing and delayed flowering. With two weeks' treatment, the plants were very severely checked, though they sprouted again from tillers (buds near the base) after being restored to normal lighting. With three weeks of dim light, all except one plant died. The yields of grain obtained from this series of pots are shown in Fig. 3, and it should also be noted that the reduced yields were produced weeks to months later than in the control plants. Thus if a nuclear winter should occur in May or June, light restriction alone could prevent cereal crops from yielding significantly.

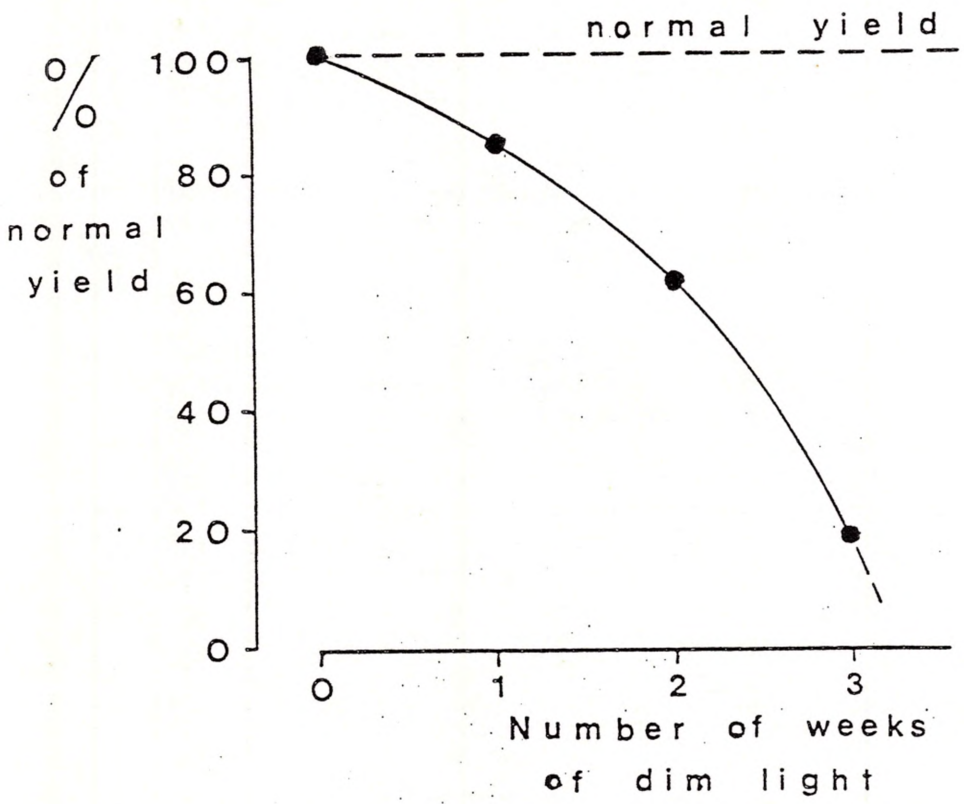

Figure 3

Reduction in the yield of wheat receiving periods of dim light during the 'growth stage'. In this preliminary trial, the spring wheat plants (variety 'Regal Durum') were grown at high light intensities before and after being given the appropriate period of dim light (1.5-2.0 Watts per M2: about 1% of the amount that saturates the photosynthetic system). Dim light treatments commenced when the plants were 6 weeks old.

At 9 weeks old, wheat plants were about to flower, and two weeks of dim light at this point caused relatively minor yellowing and checking of growth, perhaps because by this time plants have built up larger food reserves. However, the light restriction interferes with the processes of flowering and grain-setting, such that the ears remain empty and flat. The only yield came from tillers formed some time after the plants had been returned to normal conditions, and the crop was severely delayed and reduced.

So my message is that our highly bred, high-yielding cereal varieties are extremely vulnerable to reduction of sunlight in spring and summer. These were preliminary tests, and it is important that university and college departments and agricultural research stations carry out full experiments on a range of crop and pasture plants, looking at the effects of different light levels maintained for varying periods, and taking into account the interactions between sunlight, temperature and other factors.

There could be some situations in which the lowered temperatures of the nuclear winter, if not too severe, might partially offset the harmful impact of dim light. In young plants, for example, limited food reserves might last longer under cool, dim conditions than in warmer, dim conditions. Generally speaking, however, cold acts to intensify the effects of low light, or to produce extra consequences (Greene et al. 1985).

Winter cereals, for instance, are well able to stand quite severe low temperatures in January, but during mild autumn weather the same variety would be liable to frost damage if the plants had not yet become "hardened". This process requires a sequence of progressively falling temperatures to bring it about - even the hardiest trees that survive the intense cold of Canada or Siberia would be susceptible to frost damage if the temperature suddenly dropped below zero in summer or early autumn (Harwell, 1984).

Looking farther afield, many tropical plants have been shown to suffer from "chilling injury" if temperatures fall only as far as +10 degrees Centigrade, and can die after a few days at +4 degrees. Under normal circumstances, temperatures stay above about 15 degrees in much of the lowland tropics, but in a nuclear winter tropical food crops could be rapidly destroyed, even without any frosts occurring. At 10 degrees, for example, the capacity of maize plants to carry out photosynthesis is cut to 30% of normal after just two and a half days. Rice fails to set any grain if temperatures fall only to 13 degrees. The tropical forest trees that play a vital role in maintaining and restoring soil fertility for farmers in the Third World are also very susceptible to lowered temperatures.

The nuclear winter is expected to extend over the whole Northern Hemisphere, and perhaps south across the Equator (Turco et al, 1983). We are therefore talking about a widespread and comprehensive impact on world agriculture, in addition to the other direct and indirect consequences of multiple explosions of nuclear weapons. We are looking at the dislocation of global climate, the disruption of the stability of the world's ecosystems and the prospect of losing much of the food and other supplies that we harvest from them, especially the major cereal component.

In trying to understand the implications of the nuclear winter, it is important not to be misled by arguments about how large or how small the chance of nuclear war may be. An event whose consequences could be so appalling and far-reaching is a hazard whose very scale makes it an unacceptable risk for human societies to run, irrespective of its likelihood. Now we find that we have already been living under the threat of nuclear winter for 30 years without knowing it, ever since there were sufficient stockpiles of nuclear weapons and the means to deliver them to urban targets.

We can only reach a position where it is possible to "freeze" and then reduce the numbers of nuclear weapons steadily below the nuclear winter threshold if we are given accurate and up-to-date information. Regrettably, governments are often too slow to appreciate new scientific developments, and far too frightened of people learning the truth. I can best conclude by quoting Dr Donald Kennedy, President of Stanford University, USA, issuing a general warning at the Washington conference that brought the nuclear winter to scientific and public notice:

> "Yet the government, in accounting to its own citizens, bypassed the more recent information to provide false reassurance from an outdated source. We ought to worry whenever obsolete data are being used to inform public policy choices." (Ehrlich et al, 1984).

HOW RESILIENT IS THE AGRICULTURAL INDUSTRY?

George Crossley

It may seem strange, following accounts of the nuclear winter to present a paper which asks: how resilient is the agricultural industry? If previous speakers are correct then the paper would indeed be a short one. However, the public at large tend to be sceptical of scientists who predict the end of the world, and the feeling of scepticism grows when they hear eminent scientists disagreeing. For example Edward Teller, "Father of the H-bomb", recently wrote (1984):

> "Nonetheless, the myth of the nuclear apocalypse has grown steadily. Conclusive scientific studies have demonstrated that neither radiation nor atmospheric effects from any possible nuclear war could destroy life on the planet."

Now admittedly he is not actually saying that the nuclear winter is impossible. But that is not how most people will understand him. They will pick upon his statement to mean that the nuclear winter will not occur. It is therefore to the sceptic that this paper is particularly addressed. My purpose will be to describe the agricultural consequences of a nuclear war upon this country, **leaving out of account any nuclear winter effects**.

To be able to answer the question before us it is necessary to produce a scenario, so that we know what we are talking about. It has been said that, by the careful use of selective texts, almost any opinion on a specific topic can be supported by reference to the Bible. A similar statement might be made regarding Soviet strategy. However, the scenario on which our investigation of the consequences for British agriculture is based is, as far as possible, centred on authoritative readings of Soviet strategy (Meyer, 1984).

It rapidly becomes clear from these writings that **should** a major war occur, Soviet militarists believe that it would almost certainly become a nuclear war; and that once nuclear weapons were used, they would be used in large numbers. Meyer indicates what the likely targets for nuclear attack would be. They include: nuclear submarine bases, airfields, communications centres, civil and military ports, civil airports, centres of political control, and industrial targets which produce essential war goods. Hundred of such targets exist all over Britain.

There is a second strand to Soviet strategic thinking, which is emphasised by Magnus Clarke (1982): that a nuclear war must entail, not just the defeat of the enemy, but also his destruction. Clarke traces this line of thought from the early 1960s, in the works of Sokolovski (1963), to the late 1970s, quoting the Soviet *Military Historical Journal* as saying: ".... war must not simply be the defeat of the enemy, it must be his destruction. This condition has become the basis of Soviet military strategy". As a consequence of such planning we might anticipate a level of nuclear attack which goes beyond direct military and political targets but, at the same time, stops well short of attacking population centres just because they are population centres.

As well as the obvious military and political targets in Britain - such as airfields, Royal Navy bases, command and communications centres, munitions stores, regional and national centres of government - a number of industrial targets might be attacked. These might well cover the power industry, including 14 nuclear power stations and 20 conventional power stations of over 900 MW output, together accounting for 55% of generating capacity. Oil refineries and terminals would make 16 targets; North Sea gas 6; 26 steel industry targets; 19 chemical industries producing feeder chemicals for plastics manufacturing; 26 Royal Ordnance Factories; 29 non-ferrous metal producers; railway brakes and draw gear 7 targets; pharmaceuticals and agrochemicals another 16 and 11 respectively. Agriculture **per se** would not be targeted.

The total scenario would involve 430 aim points - military, political and economic. Each target would receive on average just under 0.5 Mt, though the size of the explosions would vary from 0.15 Mt for an SS 20 warhead to 1 Mt for an SS 5. Altogether Britain would receive approximately 230 Mt - not far from Home Office estimates of 200 Mt, although they suggest only 179 targets. Despite being a vast amount of explosive power, it represents only one tenth of the Soviet long-range theatre nuclear forces. Britain, because of its important military position and its strong economy, could easily justify one fifth of the Soviet long-range theatre nuclear force. Some of the reserve would be required to replace missiles which failed to work according to plan. It is clear, though, that it is not straining the Soviet Union's resources to anticipate a 200+ Mt attack.

Briefly: what would be the economic and political outcome of such an attack? Clearly there would be widespread destruction on a scale never before experienced. The country would be brought to an industrial halt and would be likely to remain that way for the foreseeable future. The power industries would be destroyed, preventing economic recovery from even beginning to take place. Political collapse and the collapse of the monetary system would also have occurred, putting the prospect of industrial revival yet further away (Crossley, 1983). It is possible that within two months, if Scientists Against Nuclear Arms (SANA) and the British Medical Association (BMA) are correct, there would be only 15 million survivors out of a population of 56 million. This is the situation from which we start and which forms the background for the future of post-holocaust agriculture.

If we now look at the immediate effects on British agriculture we can divide these into two groups: the effect of heat and the effect of fallout. The emphasis in this paper will be on two crops: barley and wheat; i.e. those which have the greatest potential for providing food.

A substantial proportion of British agriculture could be affected by the intense flash of heat from the fireballs. The losses from thermal effects would depend upon the time of year and the dryness of the crops. Should the attack occur when crops are at their driest, losses would be phenomenal. A total of over 51,000 square miles would fall within the area in which standing grain could catch fire. Losses might amount to 78% of barley, and 75% of wheat. Losses in livestock would be high at any time of year, although involving a smaller proportion of the total numbers: at a conservative estimate 5% of sheep, 12% of non-dairy cows and 28% of dairy cows might be lost. At most times of year losses from radiation would dominate, and it is to this that we now turn.

There can be no precise prediction of where fallout would land, but idealised patterns can be produced which give an indication of the likely magnitude of the problems that would be faced. From the scenario outlined above, approximately 60,000 square miles of Britain might receive a dose of over 100 rads; 4,214 sq miles receiving 3000-5000 rads and 3,031 sq miles over 5000 rads. The dose that, given over a short period, would be lethal to 50% of humans (the LD50) is 450 rads.

Radioactive fallout comes in three types: alpha, beta and gamma. Alpha we can largely ignore, as its ability to penetrate any matter is very small. Beta radiation can penetrate a few inches of air and a few millimetres of tissue and is therefore of concern only when in contact with plant or animal tissue, or when ingested. Gamma radiation is very penetrating, able to pass through several feet of steel and concrete, though losing much energy in the process. Fallout is normally given in terms of the gamma dose only, which may be appropriate in the short-term for animals which can take shelter. For the majority of livestock, and for field crops, however, beta radiation will also have some effect. Although the amounts are open to debate, it is likely that beta radiation would at least double the dose received by crops in the field (that is gamma + beta = 2 gamma). Therefore we should effectively reduce the tolerance of exposed plants by half, so that an LD 50 of 1000 to gamma alone becomes 500 to gamma plus beta. Throughout this paper I refer to plants' sensitivity to radiation in terms of beta plus gamma, which is why they may appear more sensitive than usual to those who know of their tolerance to gamma radiation alone.

As with destruction from thermal effects, damage from fallout varies with time of year. For example, should winter-sown barley receive 500 rads or greater before spring the loss is likely to be 100%, whereas the same dose after ear emergence might reduce the yield by only 14-23% of normal.

Taking into account the distribution of crops and the time of year in which the attack occurred, it was found that in the worst case 34% of grain yield was lost due to radiation alone; on average the lost yield was 16%. There would be additional losses owing to thermal effects, but because of difficulties in modelling the effect, this has not been included, except for the months July and August when thermal effects would dominate. Should the attack occur in these months, grain yield might be reduced by 76%.

Deaths from radiation amongst livestock - again taking into account the amount of shelter available at different times of the year - were also calculated. Approximately 20% of sheep may be lost; 26% of non-dairy cattle and 37% of dairy cattle. Many more would sicken, resulting in weight loss, infertility, and weakly offspring.

So much for the immediate losses - but what about the survivors? Would there be sufficient food to see them through to the first harvest, and would that harvest (leaving aside the problem of whether it could be gathered in) be sufficient to feed them? If we assume that each survivor requires 2000 calories and 8g of protein per day, then one million survivors would require 180,000 tons of wheat or barley per annum. Therefore, 40 million survivors would require 7.2 million tons of grain; 15 million survivors requiring 2.7 million tons: the two figures representing respectively the most optimistic Home Office assessment (Neal, 1971) and the most likely SANA figure (Openshaw et al, 1983). I shall in future be dealing mainly with the SANA figure, as this is the more reasonable assessment of the immediate casualties resulting from this scale of attack.

If there were 40 million survivors, then grain in store would be sufficient to feed them until the first post-attack harvest - unless the attack occurred from April onwards, in which case there would be a deficit of 0.1 million tons rising to 0.8 million tons. Consequently starvation would be inevitable. If there were only 15 million initial survivors then a food surplus would be likely, whenever the attack occurred. Food in store should be adequate for the likely number of survivors through to the first harvest.

That first harvest, assuming it can be gathered, might produce somewhere between 11 and 15 million tons of grain if the attack took place between September and June; again leaving a surplus over the 15 millions' demand for 2.7 million tons of grain. Should the attack occur in July or August, only 3.9 million tons might be harvested, still theoretically sufficient for the survivors. (See Table 1.)

<u>**Table 1. Crop production: first post-attack harvest**</u>
<u>(millions tons)</u>

Month attack occurred	Winter barley	Spring barley	Wheat	Total
Normal	2.81	6.57	7.02	16.4
Jan	1.5	6.6	6.4	14.5
Feb	2.0	6.6	5.6	14.2
Mar	2.5	4.0	5.6	12.1
Apr	2.5	3.3	5.1	10.9
May	2.5	3.9	6.4	12.8
Jun	2.5	5.8	6.4	14.7
Jul*	(2.1)		1.8	3.9
Aug*	(2.1)		1.8	3.9
Sept	1.5	6.6	4.5	12.6
Oct	1.4	6.6	6.4	14.4
Nov	1.4	6.6	6.4	14.4
Dec	1.5	6.6	6.4	14.5

* For July and August thermal effects cause greatest damage.

In the pessimistic world of post-attack predictions this seems an optimistic conclusion, but we have not considered all the problems yet. There are other factors which will tend to decrease agricultural yield still further. It is to the investigation of these problems that we now turn. The problems are: land denial to farmers; disruption of the food supply system; and lack of essential inputs. We shall look at this last-mentioned problem first.

Firstly there is the question of fuel. It is obvious that farms require petrol, diesel or electricity for nearly every operation, British agriculture using approximately 1.7% of national fuel consumption. Following a nuclear attack mains electricity would be unavailable. However, because of dislocation of transport and industry, the liquid fuel demand could be halved to 806 kt of diesel and petrol per annum. If - and it is a big "if" - all frozen fuel stocks were made available to farming, then for the first post-attack year problems from lack of fuel might not be acute. Thereafter, and probably sooner rather than later, the problem of no petroleum would have to be faced. Massed human labour would have to replace the tractor; the spade replace the plough; the reaper replace the harvester. It is inevitable that efficiency would be lost. By how much? It is a difficult question to answer. As a rough estimate, perhaps by 30% - perhaps more, perhaps less.

Not only would the quality of cultivation decrease, but so would the quantity. Fifteen million people armed with shovels could not maintain the amount of agricultural land that is used at present. If we assume that the amount of land that can be cultivated is proportional to the number of survivors, it would mean that 15 million people could cultivate 27% of the land at present used. If we allow for this, and for the 30% reduction in efficiency, we find that 15 million people could produce 3.1 million tons of grain - they require 2.7 million tons - so there is a slight surplus. We can conclude that loss of fuel alone is not necessarily sufficient to jeopardise the long-term survival of the survivors.

It should be noted that it is in fact unlikely that the loss of cultivated land would be directly proportional to the number of immediate survivors, as I have suggested. There is room for refinement in many of these calculations. I have however, where there is a large area of doubt, attempted to err on the conservative, or the optimistic, side. The most common complaint that I have had of this study is that I underestimate the problems. I do this quite consciously - I have no desire to be accused of being alarmist.

The second major group of agricultural inputs to which we turn our attention is that of fertilisers and other agrochemicals. Chemical fertilisers and British agriculture appear inseparable, the increased use of such fertilisers being largely responsible for the increase in output per acre over recent decades; though of course improved strains and other improvements in agriculture have played their part. Brown and Pilz (1969) estimated that the cessation of fertiliser supplies to US agriculture would result in a yield decrease of 40%. Taking account of the fact that British use of fertilisers at present is six times greater than the US 1969 figure (M.A.F.F., 1981), a conservative assessment might suggest that UK yields would drop by 50% without fertilisers.

The decrease in crop yield would not occur immediately but over two or three years, as supplies are used up and as that already in the ground is depleted. It is extremely unlikely that industrial recovery could even begin to get under way by this stage; thus no new stocks of fertiliser could be expected.

Stocks of pesticides would also be depleted - this would be a particular problem in the post-attack environment. It is almost certain that the numbers of insect pests will increase: most insects are unaffected by 3000 rads whereas many animals which prey upon them have an LD 50 of about 500 rads. Bacteria and fungi have very high radio-active resistance; weeds, which would be quick to colonise areas laid to waste by fire and radiation, can also be very resistant to radiation. Foxgloves, for instance, have an LD 100 of 50,000-75,000 rads compared with 2000-3000 for wheat (Peterson and Hinrichson, 1982). Fletcher (1974) suggests that without pesticides crop losses in the field and in storage might amount to 25%. Following a nuclear attack this is probably a conservative estimate, but we shall accept it anyway.

What is the outcome of this? We have seen that without fuel the 15 million survivors can produce 3.1 million tons of grain: sufficient for their needs. Now, however, we must subtract a further 75% to take account of the lack of other inputs. The result is that the survivors might produce only 0.78 million tons of grain per annum, sufficient for only 4.3 million survivors. (See Table 2.) Clearly, we have identified a critical problem. The lack of chemical inputs would mean that the population could not support itself and widespread starvation is almost certain. Even the estimate of just over 4 million survivors is optimistic as it assumes the optimum organisation of labour and distribution of resources - a most unlikely possibility in the post-attack environment.

Table 2. Harvests: second and subsequent years
(millions of tons of grain)

Pre-attack	16.4
less 75% (land unproductive)	12.0
total	4.4
less 30% (efficiency loss)	1.3
total	3.1
less 75% (lack of agrochemicals)	2.3
total	0.8

Total population that can be supported at 2000 calories per person per day: 4.32 million.

We have a few more areas at which we should look, which may further reduce food production. I propose to deal with them very briefly.

Firstly, the radiation effects on the offspring of irradiated crops and livestock. As well as reducing the yield of irradiated crops, radiation can reduce the growth and fertility of later generations. In general this would not be a serious problem in the post-attack environment. Where radiation was at its worst there would be few survivors and consequently little agriculture; thus little planting would take place of seed from the most irradiated crops. Livestock production is a similar case. Although the time of year affects the results, generally crops lost from this source might amount to 5%, a figure which would decrease over subsequent years. This would put a further strain on the ability of the harvest to support large numbers of people. The loss in livestock is more difficult to predict, but is unlikely to be of significance to most survivors.

The control and distribution of food is essential to prevent areas of localised starvation and plenty. To this end a tight-knit plan for controlling production has been officially devised. It is, however, highly unlikely that the system could operate, particularly since all the major control centres are located in cities which are probable targets, and since the wealth of fuel and good communications such a plan requires will no longer exist. Farmers will be effectively left on their own to do intuitively the best they can.

As far as food distribution is concerned, it could neither be organised efficiently, nor would there be the fuel to run it. We have already seen that it would be difficult to find 800 kt of fuel for agriculture - let alone the 3.2 Mt required for distribution (Leach. 1976).

The inevitable consequence of these findings is that the number of immediate survivors of a nuclear attack would be reduced, not only as a result of a shortage of food, but also because of the inadequate distribution of what food exists.

The unequal distribution of food is itself likely to create further problems. The hungry survivors from an inadequately fed area will migrate to other, wealthier areas looking for food. Upon reaching an affluent area they would most probably help themselves to food, with possibly disastrous effects upon the agricultural plans for that area. Consequently, although satisfying the short-term food needs of the refugees, the long-term survival of the refugees <u>and</u> the host population would be compromised. There are modern parallels to this problem in the Third World where large numbers of refugees displaced by war, famine or persecution migrate to another country, bringing the host nation to the brink of starvation or economic collapse. In these situations, however, the refugees are still largely under the control of the host nation and their security forces. In post-attack Britain no marshalling of refugees into controlled camps can be envisaged. Therefore, because of the impossibility of evenly distributing what food remains, it seems likely that the number of long-term survivors will decrease. It is impossible to estimate what the reduction in numbers might be - 10%? 25%? Who can tell? What is clear is that even the estimate of 4 million long-term survivors is beginning to look very optimistic.

Finally, in this part of the paper, we consider the problems of land denial. A nuclear attack and the need to shelter from fallout will often mean that for a fortnight at least no work can be done on the land. Will this significantly reduce the amount of food produced? The short answer is: no. There is no single agreed time when fertiliser must be applied; the tolerance of cereal crops is such that a delay of a week or two in sowing or harvesting will not significantly affect the national outcome. Fallout from a nuclear power-station apparently presents more of a problem. Fetter and Tsipis (1981) estimate that an area of 680 square miles downwind of a nuclear reactor might be experiencing doses in excess of 100 rads per annum. However this is only 8.3 rads a month, and whilst increasing the risk to those in the area, it may well be considered insignificant compared with other risks experienced in the post-attack environment. Indeed, unless in possession of appropriate equipment, people living in the area are unlikely to realise the dose they are receiving. Thus, if people survived in this area, probably the land would still be used. In short, land denial is likely to reduce yield nationally by less than 1% and is therefore ignored in my calculations.

To summarise thus far: a nuclear attack of approximately 230 Mt might leave 15 million survivors in the short term. Grain stores and other supplies of food are likely to provide sufficient food for them to survive until the first post-attack harvest can be gathered in. Fallout might reduce the yield of that harvest to 65-80% of normal, depending upon the time of year. Should the attack occur in July or August, then perhaps 76% of crops would be lost. There would still, overall, be sufficient food for the survivors.

The largest problems occur in the next and subsequent years. Lack of fuel for planting, harvesting and processing could lead to a reduction in yield of 30%; only 30% of the land previously worked might be maintained and, owing to lack of fertilisers and pesticides, a further reduction of 75% in yield could be expected on top of this. Within a few years grain production could be down to 0.8 million tons at best: sufficient for only 4 million people. Even so there would be further deaths caused by inadequate distribution of food and the chaos resulting from depredation by large numbers of refugees moving from areas of food shortage to areas initially having a surplus.

Conclusions

This study has shown that, even without taking the nuclear winter into account, the consequences of a nuclear war are far worse than is popularly imagined. Certainly they are worse than one would gather from reading either **Protect and Survive** or the long out of date **Home Defence and the Farmer**.

Is there anything that can be done to limit the effects of a nuclear war on agriculture? The answer must be: little or nothing. Prevention is the only way in which disaster can be avoided. Even if stocks of fuel and fertilisers were built up, these would provide only a finite resource. They might delay the worst consequences by a year or two, but eventually the problems of starvation and primitive agriculture would have to be faced.

The conclusions of this paper and the others presented at this conference make it clear why the authorities have been reticent about the effects on agriculture of a nuclear war. These conclusions also explain the continued delay in the revision of **Home Defence and the Farmer**. Once a nuclear war begins, little can be done to protect food production, and in the aftermath of a nuclear war food production is the single most critical factor.

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NUCLEAR WAR AND THE FARMER

Brendan Butler

In case you're wondering how it is that a farmer comes to be standing here and talking about nuclear war rather than the price of lamb or the sheep or even the latest policy document by the NFU, I think if I may I'll just give you a little bit of background about myself and Farmers for a Nuclear Free Future. My farm is in the foothills in Devon, a very lovely spot by any standards - even looking around here. I have a small beef and sheep farm with a bit of arable. Not exactly, one would have thought, the centre for deep thoughts about the nuclear threat. However, one of my neighbours, a farmer, came to ask me whether I knew of any steps that could be taken to prevent the worst effects of a nuclear war, should it happen. He asked a number of other people the same question, and our honest answer had to be that we knew nothing at all about it. It did rather shake us out of our apathy. We thought: this is a very serious matter and, as responsible professional people, we should be trying to find out just what the situation would be for our farms in the event of a nuclear war. After all, any long-term survival by people would be very much dependent on their ability to feed themselves. We decided to make enquiries.

First of all we contacted the Ministry of Agriculture. We had been told previously, on reading a booklet called Home Defence and the Farmer, that these were the people who would tell us all we ought to know. Well, they were quite honest: they said they knew nothing at all and that we must make enquiries elsewhere. So then we went to the National Farmers' Union and, to their great credit, they had been pressing for some time to find out from the Ministry and from officials in general just what was the most recent information that farmers could have, but they had had no reply. No up-date at all on the information that had been given in 1958, which was in fact Home Defence and the Farmer. We then turned to the Civil Defence people and they gave us a very good talk which we found a little too reassuring. But they actually did turn up for us Home Defence and the Farmer. Once or twice it's been reprinted but not in any up-dated fashion. It is still the latest available information and official advice to farmers. One wonders why we haven't heard any more. Personally, I suspect that it's because there is little more that can be said - and I fear this is the message that's going to be taken away with us all at the end of the conference this afternoon.

After all this, we thought we really ought to look through Home Defence and the Farmer and grasp what it was all about. We did study it in some depth and we decided we could probably cope with what is said there - we could stay in our shelters for two days, making sure our cattle and everything on the farm was all right; then come out later and get things cracking again: wash the backs of our cows off and do all the things that one ought to do to get rid of radiation.

We were reasonably happy with this, and resolved to try and circulate such information to other farmers, because there weren't any more of these booklets about. Then the Government suddenly produced Protect and Survive, and that's when we had our first real shock - because Protect and Survive says that you must stay in your shelter for up to 14 days. Now all farmers know that farming is a 24-hour/7-day-a-week job, so that staying in a shelter for 14 days, particularly for livestock farmers, is just not on. You cannot close down a farm, as you can a factory, for a fortnight, and hope to come out and find things as you left them. That effectively killed our optimism about coping. It was then we decided that we should have to explore the subject more widely.

We got hold of various scientific journals; we wrote to veterinary surgeons who knew something about it; we went to our local agricultural college and were told this, that and the other; and we made our own investigations as well. We really came up with some pretty shocking results. In a nutshell, I think I can say that we found that agriculture in the UK would be devastated. We would not only be unable to feed the expected 10 million short-term survivors that are predicted, but we would even have difficulty in feeding the pitifully few long-term survivors of perhaps 4 or 5 million. It was really this that decided us that we ought to try and get this message across to the agricultural community. Now we weren't trying to campaign. We just considered that if people are to make rational decisions about the nuclear debate, then they ought to be informed of the real facts. So we produced a guide called 'Guide to the Effects of a Nuclear Disaster on Agriculture'. This has been spoken of (by people who ought to know) as the most authoritative work so far produced. We also produced a video, which I hope a number of people will be able to see later. It lasts about 40 minutes, and shows people like myself and other farmers, vets and agricultural lecturers talking about how a nuclear war would affect them, their farms and the countryside in the future.

Here let me make it quite clear that we (Farmers for a Nuclear Free Future) are not a campaigning peace movement. We are not allied with any political bodies; we are simply concerned about making sure that the agricultural community understands what the reality of a nuclear war would be.

Our main problem was how to impart this knowledge to farmers, because whenever we have broached the subject - at a market or somewhere like that - the usual reaction was along these lines: "Well, you know, we've coped with many things. Farmers are people who can tackle practical problems; we've had troubles with the weather, we've had troubles with the economy, we've had troubles with the Government and, generally speaking, we get through and we make out; and we can't see, Mr Butler, how this is going to be any different from what we've handled in the past". What we've been concerned to show is that this is very different indeed. This is not something like a fortnight's bad weather on Dartmoor. It's far far worse than anything like that and it is something that will just not go away. We had really to get this message over if we could. We also had to try and avoid the rather arid and detached terminology which has to be used by scientists and bring it down into the real and practical world of the farmer; to explain how in fact it would affect him and his livestock and his crops.

Now I want to try and do this today by portraying the effects of a nuclear war on a mixed farm - from the pre-attack warning period up to the preparation for the second harvest some 18 months later. Now this is no attempt to shock, because from what you have heard this morning you know that these things need no exaggeration and that of course they are not certainties. I am not pretending that the things I am going to say are in any way certain, but they are probabilities and very real probabilities at that. There is only one certain way to find out, but if we were to do that, it's very doubtful that anyone would be interested enough to write up the results.

So that I shall not be accused of having denied our farmer (because we're going to take a specific farm and a specific farmer) a reasonable chance, the attack I am going to describe will be what might euphemistically be called of modest proportions. We shall assume that 3000 Megatons will be falling around Europe and Russia and America, of which 230 Megatons would fall on the UK. Now although this is my own interpretation, and precise predictions are very difficult, I am indebted to Dr John Shepherd, a physicist at Exeter University. He has studied my paper and he's helped me with a month-by-month account of how he thinks the nuclear winter and the "nuclear summer" will affect the farm.

In order to show the effects on as many enterprises as possible, this particular farm has a dairy, an intensive piggery of around 1000 fattening pigs, a flock of breeding ewes, poultry for the house, and some arable, comprising barley and potatoes (barley mainly kept for stock feed). The buildings are of fairly modern construction, light and airy, with some traditional buildings as well, of brick and stone, and a silo and, of course the ordinary hay barn and straw barn. The farm is dependent on mains electricity and water: but in order again to give the farmer the best chance, he has his own stream running through the farm as well as his own generator for electricity. Now as to the proximity of the attack, it won't be a direct hit which would blast or burn him off the earth; it's about 20 miles away, it's going to be a 1 Megaton explosion, and really there should be little blast damage to worry about. However, the radioactive levels will be high, so that we are going to be concerned with those and with the nuclear winter. Of course again the time of the attack is critical, as we heard this morning. If the attack comes in the spring, then you have three winters - the preceding winter, the nuclear winter and the following winter, which will be very critical indeed. Mine's going to happen in mid-October; in fact I'm going to say it's here and now, today, to give us a much better idea of the timescale as well, the nuclear winter coinciding with the natural winter. Altogether I think it can be fairly said that I am taking the best options.

What's the position on the farm at the moment? Well, most crops are harvested and the land either re-sown or under fallow. Some of the potatoes are in the barn, sorted and covered, some are still in the fields. The winter barley is drilled and some is emerging. So we come to the 48-hour warning (that is today). Now this has followed a period of tension, but I doubt if we would have been told any earlier that we ought to be taking nuclear precautions, because the political implications of saying this would be so great that no government would decide to do that. So our man, unless he already really believed this was going to happen, has 48 hours to do something about it. He obviously listens to the radio and watches television; and hopefully, his friendly farm warden will come round and tell him what he ought to be doing and how he ought to be doing it. I'm sure the farm warden will be a very useful man, but although he is acting for 20 farmers we will assume he manages to visit them all.

Now what is going to be the first reaction to the 48-hour warning? Well, I know what mine would be - confusion, fright, what to do first. I think crises affect people differently and no doubt some might lose all rational control at this point; in my view not enough account has been taken of this. I mean, are we really going to survive the nuclear war psychologically apart from physically? There has not been a great deal of talk about it and I think there ought to be. However, our man is going to be made of much sterner stuff than I am. He will probably first of all still believe it won't happen or, if it does, that the scientists have got it completely wrong. His first thoughts of course will be for the family, and he's going to have time taken up on the first day at least making his fallout shelter and getting his water, food and light etc., working there. Then he will turn to his stock, knowing this time that he will have to stay in the shelter for up to 14 days before he can come out and tend them again. I think he has just got to resign himself to the fact that little can be done for the majority of his stock, particularly as water is going to be one of the main problems; when the bomb explodes the electricity supply will be cut and so will his water supply. The buildings will offer them some protection against radiation, so that I do think he will get all his stock inside if he can. He will be able to get a certain amount of water in to them, and perhaps as much food as required in to some of them anyway. But the main problem is going to be radiation. If possible he ought to house all the stock in a sealed building so that fallout doesn't enter and they will have enough food and enough water to last them a fortnight or longer until he can come out and look after them again. Unfortunately, when one puts animals in a sealed building, pneumonia might well start to run riot and there could be all kinds of other lung problems as well.

Water is the next problem. The freezing temperatures over those 14 days are also going to make it very difficult for stock to be able to take in the water they need. Nor will there be time to dig and cover wells and reservoirs, put in filters, and so on.

Cold is unlikely to become a major factor until later on in the 14 days. As for food, he can probably put in enough bales to keep them going. The cows will be the worst problem because he won't be able to milk them. He might say to himself "right, I'll leave the family and I'll go and live with the cows and I'll milk them twice a day and hopefully things will be okay". I don't believe any man is going to do that. I don't believe that he would be able to milk them, say he's got 60 to 100 cows, twice a day for 14 days by hand. I think what he would do, and what the warden would advise, is to put them in a building, give them what water and food he can, and turn in the followers in the hope that they will suckle here and there and perhaps limit the distress.

Sheep are less tolerant to radiation but a lot more tolerant to lack of water. They will be eating dry food unless he can manage to put in silage, but they might have a reasonable chance of getting through.

The pigs will pose quite a problem for our farmer. If he turns them out to forage for themselves, 1000 pigs rampaging round the countryside is not something everybody is going to be happy about - especially if the alert should turn out to be a false alarm. Should he kill them all off or should he save his ammunition for those animals that are in distress later on? Or should he just feed them, water them and leave them in the hope that nothing is going to happen? I think he would choose the last-mentioned. Now pigs will die after only two or three days, because they suffer from salt poisoning, I'm told, if they haven't enough water. The warden would probably suggest building what he would call not a Noah's ark but a nuclear ark - a sealed building where our farmer could take his hardier animals, give them water, give them food, and just see whether in fact they could survive. He could probably do that with a very limited number of stock (10 or 15). He would want to put in a horse or two if he had any, because they could be very useful as his only source of energy in the future; and oxen also, because oxen will make very good draught animals.

The poultry - he would want to look after those. He would close them up, I think, give them as much food as they wanted, and they would probably produce all the eggs he would need in the future. Nor would they be greatly worried by the radiation - they have quite a high tolerance to radiation.

He would cover up his fodder stores and potatoes, making sure that radiation didn't get to them so that they could be used later on. Also he'd have to cover up the tractor to protect that from radiation.

He would take to his shelter and wait, meanwhile keeping in touch with the news by radio. Next he would hear the explosion, absolutely deafeningly although 20 miles away; and I've no doubt that even from his refuge he would see the light flash.

Well, the electromagnetic pulse would immediately break all communications. He would have no idea from then on what was happening outside, and I should imagine this to be a very, very distressing time for both the farmer and his family.

After a day or two he would doubtless start to hear his animals in distress, as most farmhouses are near the stock buildings. He would know that the pigs were probably cannibalising each other, and that the cows were deeply distressed by their milk condition. He would, I think, want to come out. I know I should, just to see what was happening. In any case, his fallout room would be uncomfortable and it would get very cold indeed. It would probably go down to well below freezing at the end of his 14 days. I don't think he'll stay in that long. I know I couldn't. I'm going to say that on the 12th day he dons his protective clothing and goes outside. What does he find?

Well, it'll be nothing like the world he last saw, if what we understand is correct. It will be dark and it will be cold and everything he touches will be contaminated with radiation. Now that is the reality of it - that's what one would have to face if we had a nuclear war. Light levels would probably be about those of the moon at night and the temperatures could be as low as about -15 degrees centigrade. He would probably find all kinds of dead animals around. The sky would be covered with dark clouds and the air would be heavy with soot and smog. I doubt if he would see any blast or burn damage.

His first thoughts after he'd imbibed this would be for his livestock. The cows I would say would be very distressed, there might be one or two dead at this time from radiation sickness, they would certainly be suffering from beta burns, septicaemia because they hadn't been milked, they would be cold (a number of them I should think would be blind) and they would all be lacking water. The pigs would be in carnage, they would all be dead. The sheep I would suggest had fared rather better, there would be a number alive and one would hope that perhaps by shearing them at some future date you would be able to get the radiation out of the fleece. They would lack water but I don't think this would worry them to any great extent.

The nuclear ark - well I think this would be a far better proposition, and he would find that a number of those animals were coming through and coming through quite well - though again they would be very subject to lack of water. So I think as he could only stay out for perhaps an hour and must do all he could very quickly, he would attempt to water those few sheep and the nuclear ark. To do this he would probably have to break quite a considerable amount of ice in his stream. He would be aware that the water is contaminated but he would really have no choice as he couldn't really filter it. Realising that he had probably already been out too long he would go back to his shelter, and I would say by this time he would be pretty apathetic and demoralised as well as being very cold.

I've little doubt that this is the routine that he would have to follow in subsequent days until about mid-November when the family would say "Look we can't take this any more - we must come out, build ourselves a fire and try and get some comfort even if we are going to get irradiated".

He will also be attempting to filter the water to extract some of the radiation (and this will again be a great problem) - not just for the family, but to stop the cattle and sheep ingesting radiation which will by this time be in the ice and in the water. He will find that all the corn he has drilled has been killed by cold and radiation. The unharvested potatoes will be frozen, but the corn in the silo and the potatoes in the barn will be all right as far as he knows. I would also think by this time the rats are beginning to eat the carcasses, because they are very resistant to radiation and live underground. He will wonder to himself perhaps whether he can shift the carcasses; but he won't be able to get the tractor to start at minus 15 degrees - and anyway, how on earth could he possibly dig holes for the carcasses to be taken to?

So on our timescale, by January 1985 (I am told by the scientists), the cloud will be starting to clear and the temperatures to rise. But they will only be rising from the minus quantity towards zero. As the clouds clear a new problem is going to arise: ultraviolet radiation. This means that he will have to make sure he wears dark glasses, and that he tries to protect those animals in the nuclear ark and the sheep from the effects of the ultraviolet radiation, which can give cataract blindness. It also suppresses photosynthesis, so that any plant growth that might be getting started will have another setback. Probably by this time he will have very few stock left alive, apart from those in the nuclear ark.

As the temperature rises I think there would be some new hope. He would ask himself, "will there be a spring?". In the past one could always rely on spring. Whatever had happened to you in the past as a farmer, the spring was always going to come and you'd go forward and feel that things were going to be much better. One has, as a farmer, to be optimistic. But this time when the spring came, it would be nothing like what he'd known before. The temperatures in April would probably still be around zero, the ground still iron hard and impossible to cultivate, radiation levels still high due to the continuing fallout - which the scientists now believe is going to go on for some considerable time because of the tremendous number of clouds up there that will keep on bringing fallout down over a much longer period than was previously considered likely.

By June the temperatures will have risen sufficiently for plant growth. It is possible that grass might show signs of greening up, for it is extremely tolerant to radiation. The problem about that is, seeing it greening up, he might be encouraged to put his stock on it. But its tolerance means that it absorbs radiation, and the stock would ingest it from the grass; so this is a circle in which one goes round and round. So he would decide, even though the grass was growing, not to turn his animals out but to keep them in until radiation levels were much lower. There would be no likelihood of taking a corn crop that season. Then insects would start to appear - (we are now three or four degrees Centigrade above freezing point) - and they would attack the carcasses. It would be a very good thing, as it would help to get rid of them, though the stench would be absolutely ghastly.

The family food would be grain and eggs, and perhaps the occasional hen if they were lucky, together with the roots. They wouldn't be doing too badly at all. However, they would have to make sure they stood up to any marauders. There is no doubt that people from the towns will reach the farm, saying "Look we've escaped; can we have some of your food?" If he says to them, "No, you may be starving, but all that in the silo is wanted for Joe Bloggs 50 miles away, and it's being organised by the Agricultural Officer, and I'm going to put this lot in the ground later on so that you can be fed in a year or two years' time" - it won't cut much ice. They will be pretty hard men and will try desperately to get food from him, so I think farmers would have to be prepared for that problem as well.

He and the farm warden now decide that they won't go ahead that winter, but will cultivate in the following spring when the chances of obtaining a decent crop will be much better. The last of the seed fertiliser and diesel fuel must not be wasted by an autumn planting that could turn out to be disastrous if the temperatures downturned again and radiation remained high. So somehow they get through that winter, the winter of 1985/86 - with what mental stress and physical problems can only be very dimly imagined. At any rate we shall assume he gets through and another spring comes. The temperatures do start to rise, though not as high as in a normal spring; but at least it looks as though it is possible to cultivate and get things going again. This is really what everyone's been waiting for. However, you've still got radiation, you've still got the ultraviolet light problems; you're still all covered up. I think that at this time the farmer is going to be in a bit of a dilemma. Is he going to go out and risk his life cultivating areas of ground, using up his precious fuel, using his own seed-corn to produce food to help people somewhere else? Or is he going to say to himself, "No, I'm not going to sit on the tractor and be irradiated by all the dust - I'm going to stay in, I'm going to keep my family well; we are going to eat our poultry and corn and our potatoes; and we'll plant patches of this, that and the other, and we'll do quite nicely we hope". I think many people might feel just like that.

However, our man is made of different stuff; he decides to go ahead and cultivate. He uses up his remaining fuel and fertilizer, he plants his corn and potatoes; and now comes harvest-time 1986, and the yields, I should have thought, would be about half those of normal, due mainly to the continuing radiation problems, the ultraviolet light, and the general lower temperatures - but not bad in the circumstances. He'd say to himself at that time, "Who on earth would have thought I could have done this?". The corn would no doubt be distributed by the warden if he is still around, but he would leave seed for the following year and the potato crop would be lifted, although it would be pretty poor since it needs a large input of fertilizer which just wouldn't be available.

At this time it could be said that our man has won through, but I think you've got to ask what he's won through to. That's the real question. Future harvests would be very poor as they would rely on human energy and possibly also a few horses and oxen. There will be no fertilizers, no fuel, no pesticides and no weedkillers. He will have to continue from there in a world that is polluted with radiation; his lifespan and that of his offspring will be short and his whole existence comparable to that of the animals. Now there is a belief - and I think a dangerous one - that at this period we will be back to mediaeval times; and in mediaeval times one hoped there were always better things to come. But at no time in the Middle Ages were conditions anything like this. Not even the worst ravages of the plague perverted the course of nature as the nuclear bomb will do; then the sun still shone, grass grew and animals thrived. I think it would be very wrong to encourage a belief in the possibility of a sturdy and self-reliant return to the soil by nuclear survivors. The unfortunate few who get through would be in a world totally unlike that of any other human experience. In our Guide we use a Kenyan proverb which sums up everything we feel about it, and we ignore it at our peril. It says this: "Treat the earth well. It was not given to us by our parents. It was loaned to us by our children."

Critique of 'Civil Defence and the Farmer'

(Ministry of Agriculture, Fisheries and Food; published 7/6/85)

Pressure from farmers and their organisations for up-to-date advice on the effects of nuclear weapons is acknowledged to have stimulated this long-overdue revision of 'Home Defence and the Farmer', which has been out of print since 1962. In style, presentation and some of the content, it has definitely been improved, but because there are serious omissions and more than 25 misleading statements, it fails to measure up to the magnitude of the task it sets itself.

Throughout the booklet, farmers are being exhorted to plan, check, prepare and carry out measures intended to protect personnel, livestock and stored feedstuffs in order to maintain the nation's food supplies and help its recovery. Yet the time-scale throughout is in days and weeks, failing to address the equally pressing problems which a surviving farmer might have to grapple with over months and years. Thus he should "aim to have an emergency water supply for up to 14 days", and a table is provided showing the minimum requirements for livestock (a herd of 30 adult cows needing about 300,000 litres). Yet it is hardly conceivable that in the aftermath of nuclear war the "likely ... disruption of mains water and power supplies" would be repaired and restored in a fortnight.

The key to this exclusive consideration of the short-term, which also characterised the old version, is that the compilers choose to concentrate upon local radioactive fallout, and to assume that the fine dust particles could essentially be kept out of cowsheds, barns and intensive livestock units. The new document includes a reference to longer-lived radioisotopes getting into the food chain, but unfortunately is inferior to the earlier version in that it has lost the informative map of Britain showing the lethal plume of fallout travelling 200 miles or so across the countryside. This time we are also assured that farms and agricultural areas as such would be unlikely to be targets for direct attack, ignoring the frequency of targets (now including the dispersed cruise missile launchers) that are in or adjacent to farmland.

The advice on radiation is further weakened by the omission of any reference to global fallout, which has been known for decades, and (despite a statement to the contrary) the more recently recognised intermediate time-scale fallout, which could give unsheltered humans and livestock in our latitudes an additional average radiation burden over 500 times the normal background levels. In addition, the antiquated notion of "safe limits" is perpetuated, although it has been widely accepted by radiation scientists for many years that there is no threshold below which its effects can be ignored, all radiation being potentially harmful. An extraordinary error in paragraph 37 is the statement that protection against the effects of alpha, beta and gamma radiation is possible - the only protection is not to receive it. Strangely, too, there is no mention of the one method known of removing ingested radioisotopes that have reached the blood stream, namely the taking of iodide tablets to encourage excretion of Iodine-131.

The most serious omission is the lack of any mention of the nuclear winter, with its risk of severe climatic perturbations due to the very large quantities of dust and smoke particles forced into the atmosphere, blocking sunlight and sharply reducing temperatures. To try to justify this on the grounds that "at the time this booklet was published these theories ..... were still being investigated" is naive in the extreme, flying as it does in the face of widespread scientific opinion and concern, and ignoring a variety of published books, articles and reports. Was publication of 'Civil Defence and the Farmer' perhaps timed to precede the imminent release of the findings of the prestigious international Scientific Committee on Problems of the Environment (SCOPE), which like the U.S. National Academy of Science Report may well confirm the risk of nuclear winter? In any case, it would indeed be crazy if scientists were not still investigating what could be the largest threat ever to face human civilisations.

Although the standard U.S. reference source, Glasstone & Dolan's 'Effects of Nuclear Weapons' is cited, and there are three useful tables, there is a dearth of numerical data on the distances at which direct effects of nuclear explosions may be expected. Farmers are unlikely to grasp the scale of the damage from expressions such as "considerable distances" and "in the vicinity of", and the 5 miles quoted for blast damage is largely meaningless without a statement as to the size of weapon exploding. Fires are correctly included as an important effect, but the question of deaths and injuries to livestock from burns is not dealt with, though Dr George Crossley published estimates a year ago which suggested that of the order of ten million cows and sheep could come into this category, following a 260 Megaton attack on Britain.

A further critical weakness of the booklet is that time and time again it is assumed that communication with farmers would exist after nuclear attack, and also that "in time of crisis, the advice given here would be supplemented by advice on television, radio and in the press". Surely, if civil defence is to have any chance at all of saving lives through traumas of this magnitude and duration, it would have to have been prepared in detail, and its farm wardens trained well in advance? Farmers are certainly resourceful, but they need to be provided with the best available information if they are to make wise decisions about these questions. This booklet fails to treat them as responsible adults, yet in the section on 'Shelter supplies' it even forgets to remind them to take the matches, and the chemical to go in the toilet bucket.

Alan Longman

COULD BRITAIN BE EFFECTIVELY DEFENDED WITH CONVENTIONAL WEAPONS?

Charles Woolfson

In considering the question "Can Britain be defended using only conventional weapons?", I think we have to be aware of people's genuine fear that if we abandoned our nuclear forces, we would somehow or other be left defenceless. I believe this fear is the kernel of the problem we face and it is what makes the arguments for non-nuclear conventional defence so important.

Let me begin talking about Britain by making it clear that I have in mind conventional weaponry to be used by a professional army. The Defence Research Trust which is sponsoring this gathering, and its parent organisation Just Defence on whose behalf I am speaking, have examined in some detail the kinds of deployment of personnel and equipment that would provide us with an **effective conventional defence system.** Now these are very different in structure and make-up from our current armed forces. It could be argued that our existing conventional armed forces are not really designed for defence in the true sense of the word. They are to some extent aggressive, they are threatening, and indeed their defensive capability is seen to lie precisely in this area. However, a credible defence strategy need not rest simply on instilling fear of retaliation in the other side. The Korean air-liner tragedy has graphically illustrated the heightening of Soviet feelings of insecurity and of threat from the outside, and has shown the kind of disastrous over-reaction that can take place in such a climate of fear and threat. As opposed to fear and tension, however, we can create confidence in the other side - in much the way that for instance Noel Gayler and his colleagues have suggested - by demonstrating to them that no threat exists unless we are attacked.

To achieve that, we must adopt an overall military posture which is defensive both in its intent and in its appearance. In other words, we have to remove from our own armed forces those elements which are adapted, for example, to invading or inflicting great internal damage on other nations. We should concentrate instead on elements which are well adapted to defence but maladapted to aggression. The idea, then, is to switch over a period of time to a different inventory of weapons and to different military strategies - those which are non-aggressive and non-threatening. Although the details and phasing-in of such a package would obviously be a matter for political debate and for discussion inside the armed forces, in what follows I attempt to describe the kind of armed structure this new approach would mean specifically for Britain, and why it is attracting increasing attention.

For the Army, I think that tanks would probably no longer be used. Instead the concentration would be on a mobile infantry with high fire-power, using surface-to-air missiles or short-range surface-to-surface missiles; and deploying artillery and helicopter ground-support systems. For the Navy, we should be looking towards a strengthening of coastal defences. This would involve a gradual phasing-out of large warships and aircraft-carriers. Instead, naval forces would emphasise smaller coastal patrol vessels equipped, perhaps, with anti-submarine mines, anti-ship missiles, and so on. For the Air Force, there would be a phasing-out of strike aircraft so that, for example, the multi-role combat aircraft Tornado would be scrapped, since it possesses a long-range nuclear strike capability.

Instead, we would be concentrating on single-role interceptors which would defend our air-space against intruders. And finally of course, we would want to consider abandoning the development of nuclear weapons with first-strike capability; I have in mind here systems such as Trident which are very expensive and also greatly exceed any of our strictly territorial defensive needs. Indeed, I would argue that the entire non-nuclear defence strategy is likely to prove less costly than our existing military strategy and equally if not more effective - both because of the consequent lessening of tension and fear, and because of the traditional advantages of defensive warfare, which have been given an extra boost by recent developments in technology. It is generally agreed by military strategists that a well-prepared defender can hold off an attacker with about one-third of his capability, because the defender's strongholds are already in position and because he has the advantage of detailed knowledge of the terrain.

I should like to examine this in a little more detail, and here we move into the science-fiction world of advanced technology or Emerging Technology - ET for short. It is this Emerging Technology which is rapidly transforming the shape of tomorrow's, if not also today's, battlefields. The technology which has produced the awesome first-strike weapons such as Trident and MX has also revolutionised conventional warfare and weapons systems; this has made non-nuclear defence credible in a way that it has never been before. For instance, we can now produce sensors - that is to say listening devices, acoustic, chemical, infra-red warning devices, that can actually "pick up" exhaust fumes and heat from approaching tank columns. This means it is now extremely difficult to launch a mass tank attack without detection by the other side. In addition, there are now highly accurate and compact anti-tank missiles which can be guided by laser beams and which can be fixed to mobile launchers or fired from the shoulder by two-man mobile units.

There are also, for surveillance purposes, remotely-piloted aircraft and satellite scanners which can feed information to ground-control computers which in turn control sophisticated electronic fire-and-forget weapons. You simply press the button and the weapon finds its target. Moreover, in the late 1980s we are going to see what are called "autonomous homing missiles"; that is to say, missiles once fired, hitting their target; then the follow-on missile will observe this and will, with its electronic brain automatically re-route itself on to a secondary target. This is the scale of developments that we are now talking about in contemporary armaments. Such micro-electronic weapons are deadly accurate and very powerful. They are also relatively cheap to produce and relatively effective when compared with the older, more cumbersome and very complex war-fighting weapons such as tanks, aircraft carriers, battleships and strike aircraft - all extremely sophisticated pieces of equipment which are liable to malfunction just by virtue of their complexity.

Let me give you some figures - just to help you form an idea of the scale of what I am talking about. A missile costing fifty thousand dollars can bring down an aircraft costing ten million dollars; or a missile costing only four thousand dollars can destroy a tank worth one million dollars. The effectiveness of these new precision missiles was first demonstrated in the 1973 Arab-Israeli war by the Soviet-made Sagger anti-tank missile which literally stopped the Israeli tanks in their tracks. So we are, as General Loesser has said, in the age of "smart" weapons or, in military terms, "precision-guided munitions". These precision-guided munitions are eminently suitable for defence of territory against invasion; hence their relevance to Europe and in particular to the United Kingdom. They are light, mobile, capable of decentralised deployment by small mobile units of relatively unskilled personnel, the so-called "techno-commandos" in the jargon. Of course, they would be located in strategic positions and capable of carrying out a war of attrition.

I should like to make the point here that much of military strategy is governed by tradition and the experience of past wars. The major victories in World War II were the ones that stopped the enemy after he had taken territory from the other side. I have in mind, for example, El Alamein, and the battle of Kursk in which the Germans fielded 3000 tanks and lost 2900. However, what I am suggesting to you is that the doctrine of regaining lost territory still dominates military thinking. What we should be thinking about instead is a war of attrition which bogs down the advancing enemy force; it does not surrender much ground in the first place, which then has to be won back by a long and painful process of recovery. The deployment of conventional forces using precision-guided munitions in a defensive manner could extract an unacceptably high entry-price from an invader in terms of losses of personnel and equipment and, above all, in terms of time taken to establish control over hostile territory.

A surprise blitzkrieg attack by the Warsaw Pact has to be fast to succeed. It also has to penetrate deeply. To be successful, a Soviet blitzkrieg on Western Europe, based on a mass tank attack with paratroop support and so on, would have to over-run Western forces and, in particular, seize missile installations, in as short a time as two weeks at the outside, in order to produce a military fait accompli; and according to their military manuals, this is the kind of war the Soviets envisage waging. Now, even if the tanks did not break down, even if the tank drivers did not get lost (and there can be quite a bit of debate about that), the kind of military strategy that I am talking about would probably be sufficient to slow down any advance to a snail's pace. This is not just my opinion, and I'd like to quote to you from an article in Scientific American by Paul Walker (1981) on "Precision-Guided Weapons", where he points out the effectiveness of "smart" anti-tank weapons in any future land warfare involving mass tank attacks. He says :

> "In short, it seems that the day of the blitzkrieg is over. It could be argued that appropriate combined arms including infantry, artillery and armour can still prevail against anti-tank defences, but technical evidence, however, does not substantiate this view. Even on a dirty and chaotic battlefield, anti-tank weapons will be, if they are not already, too capable and available in numbers too large for them to be defeated by artillery barrages and by tank thrusts. Blitzkrieg attacks will become suicidal and as a result major defensive positions will probably be stabilised throughout the front. Some tank commanders may still believe that the best anti-tank weapon is a tank. Yet the heavy tank of today, weighing 60 tons and capable of a maximum speed of 50 miles per hour, is being out-ranged and under-priced by accurate missiles, both land and air-based. The future of land battle, it seems, lies not with such ponderous, costly and easily detectable armour but rather with light, mobile, cheap and therefore more numerous missile-armed jeeps or reconnaissance vehicles."

Paul Walker also suggests that tanks, combat support aircraft and large surface ships will ultimately become obsolete for war-fighting tasks, being relegated to a largely ceremonial role, put on display at May Day and the American Memorial Day celebrations.

Now, in what I have been saying there is apparent an underlying assumption that the Soviet Union is indeed a threat to Western Europe and that it would, unless deterred by nuclear means, roll across the Border from East Germany in a mass tank invasion. Nonetheless I think that even some military men would now argue that that is a questionable assumption - particularly if one looks at the history of the Soviet Union. Unlike the US, for example, it has only rarely deployed forces outside its own borders or its own immediate sphere of interest in Eastern Europe. Afghanistan, for example, it could be argued, was not so much a move towards world domination as an attempt to reinforce what was seen as a legitimate buffer zone area in terms of Soviet defensive and security needs. Let me quote to you from the retired U.S. Rear-Admiral Gene La Roque (1983), writing in the <u>Annals of the American Academy of Political and Social Science</u>, where he says:

> "I do not believe that there has ever been any evidence that the Soviets were planning to launch a military attack on the United States or Western Europe. At no time in their history would they have had anything to gain from such an attack nor can I visualise any set of circumstances when it would be to their advantage."

I think it is worth recalling that it was the Soviet Union that was invaded in the last war, that the Soviets lost twenty million war dead, and that their needs for security are very much dictated by their experiences at that time.

This still leaves open the question of possible nuclear blackmail by the Soviet Union if we were to abandon our nuclear weapons. I think, however, that the case for non-nuclear defence partly answers this question. We can, I believe, link our non-provocative, non-nuclear defence policy to a long-term de-nuclearisation of Europe. In my view what we are looking for is the withdrawal of all tactical nuclear weapons from the European theatre; and indeed various proposals have been put forward in that direction. We ourselves could either remain within or be outwith the structure of NATO. It is noteworthy that neither Norway (although a member of NATO) nor Canada allows nuclear weapons on their soil during peace time.

To sum up: I think it is now possible, or it soon will be, to provide a reasonable guarantee of territorial security without a nuclear component. We could train, organise and equip appropriate conventional forces and deploy them in a non-offensive and therefore non-provocative manner. Our deterrence would lie in resistance to aggression by territorial defence rather than by nuclear retaliation. Such regular armed forces could be backed by irregular guerrilla formations acting in concert with forms of civil resistance - all in a sense demonstrating our political resolve not to submit to any outside invading force. At the end of the day, however, as long as nuclear weapons exist (especially with their implied threat of the nuclear winter), there can never be a meaningful guarantee of <u>security</u> in any real sense of the word.

I should like to end with a quotation from one of the non-nuclear theorists, Anders Boserup (1982).

> "Genuine security and arms restraint can only be based on the notion of preserving peace by means of forces ample for defence but with offensive capabilities reduced to a minimum. Only in this way can one State reconcile its demands for security with other States' rights to it."

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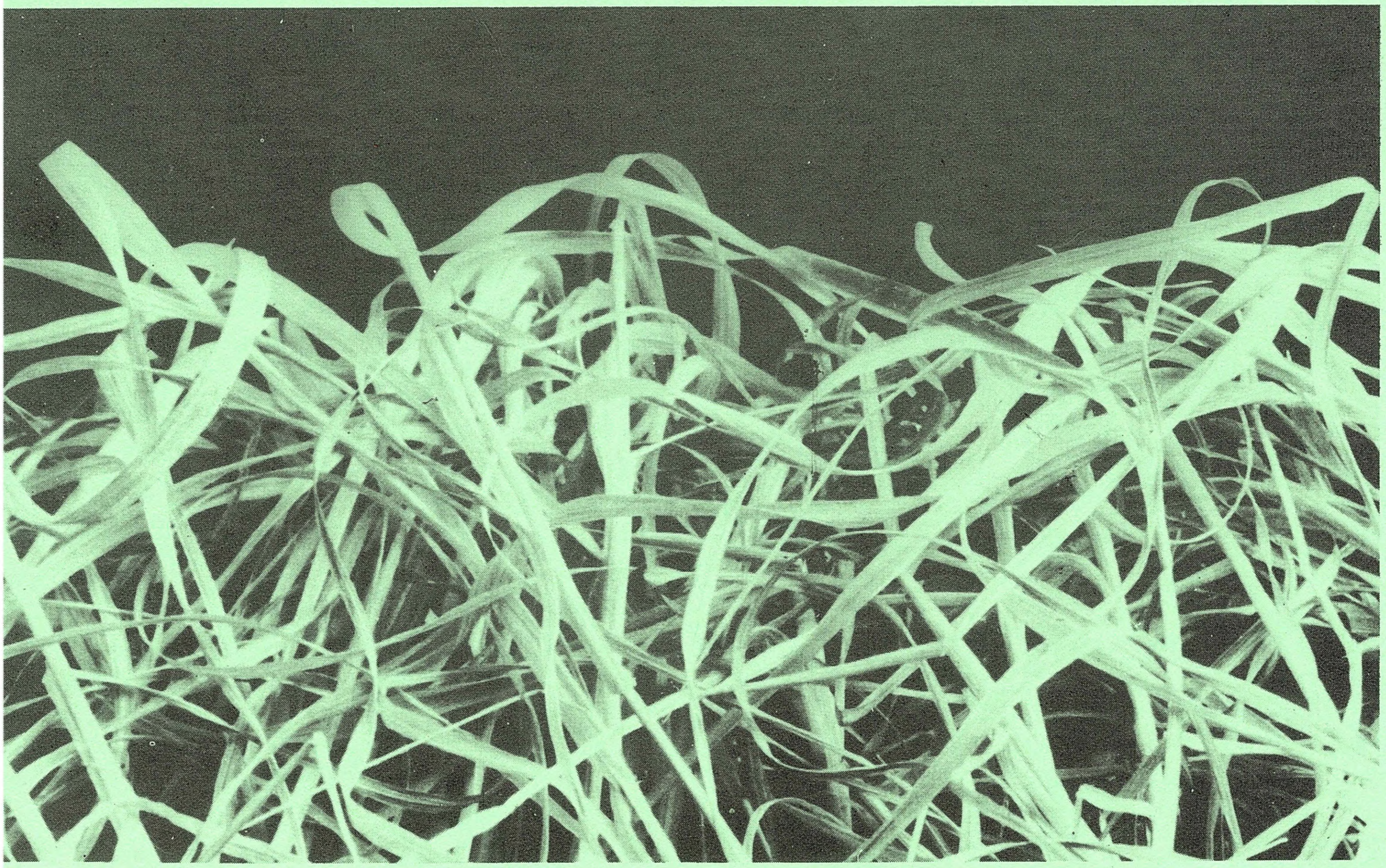

A test with spring wheat (variety "Regal Durum"), showing the effect of restriction of light.
Above top : Plants grown throughout in normal light conditions.
Above : Plants given 3 weeks of dim light, starting when 6 weeks old. Although they were returned to normal conditions, only a single plant survived. (As seen in BBC2's "On the 8th Day").