Guide to the Effects of a Nuclear Disaster on Agriculture

Treat the earth well–
It was not given to us
By our parents;
It was loaned to us
By our children.

Kenyan proverb

GUIDE TO THE EFFECTS OF A NUCLEAR DISASTER ON AGRICULTURE

Produced by Farmers for a Nuclear Free Future

CONTENTS

PREFACE TO THE SECOND EDITION

The five sections comprising this guide were first published separately. We found, however, that most people requested the complete set and we have therefore reissued them, in the present format, under one cover.

The demand for this information, referred to by the BBC (On Your Farm, March 1984) as, "the most authoritative that is readily available", has been far beyond our expectations. We very much hope that this attention reflects the fact that many more people are becoming concerned by the nuclear debate and that they wish to gain an accurate understanding of the real issues involved.

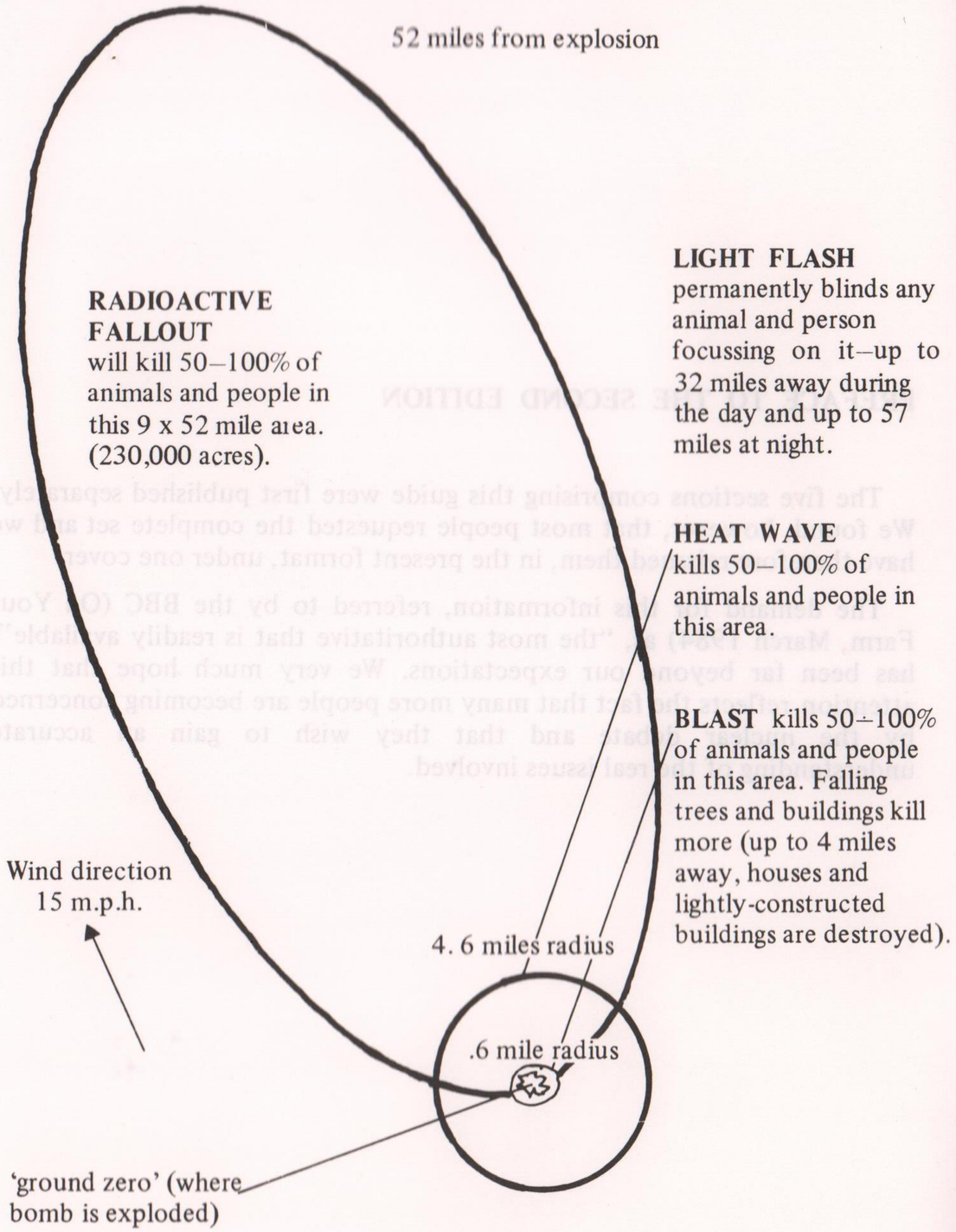


Diagram of the effects of a one megaton nuclear explosion

INTRODUCTION

After a nuclear war man's greatest lifeline to survival would be the continuance of some form of agriculture to provide him with food. We therefore find it extremely unsatisfactory that no government has yet seen fit to update and correct the information given to farmers in the H.M.S.O. publication, *Home Defence and the Farmer* (1958), which outlined the effects of a nuclear attack on agriculture and the possible ways in which it might be mitigated. It is for this reason that we, as farmers, have undertaken this work, and using the latest information have prepared this guide to help farmers, agriculturalists, and others interested in the countryside, to understand how farming would be affected by a nuclear disaster. We have tried to present all this information in an easily readable form so that the problems facing agriculture, in the nuclear age, can be more readily understood.

A nuclear disaster would have a devastating effect upon the countryside with its farms, livestock, crops and wildlife and surviving farmers would be expected to play a vital role in a post-nuclear attack society, yet, at the moment, most farmers are unaware of the agricultural consequences of nuclear war. Typically the questions they ask are:–

CAN I PROTECT MY FARM?
WHEN WILL I BE ABLE TO GROW CROPS AGAIN?
HOW DOES RADIATION AFFECT CROPS AND LIVESTOCK?

This guide attempts to answer these and many other questions in the belief that the more knowledge people have, the more likely it is that informed and therefore sensible decisions will be made about nuclear issues.

When reading this guide it should be remembered that although we discuss the practical consequences of the effects of heat, blast and radiation we believe that *these may well be overwhelmed by the expected catastrophic climatic and ecological changes.* Nevertheless we have retained these discussions because the fundamental effects of heat, blast and radiation would be experienced before the climatic changes occur, after they have passed away, or at levels of nuclear exchange below 100 megatons when the climatic changes are unlikely to be triggered.

Every care has been taken to ensure that the facts are correct but in an area, as new and contentious as this, where safety standards and casualty figures are regularly being challenged and revised, readers are advised to cross check details if they wish to use them as a basis for their own safety precautions.

Several difficulties are encountered when the after effects of a nuclear attack are discussed because no-one can know:–

How many bombs will be dropped.
What size they will be.
Whether they will be ground-burst, air-burst or both.
What areas will be targeted.
The strength of the prevailing wind, which will affect the area covered by radioactive fallout and fire damage.
The time of year of the attack, which will affect crop production and yields.

The variability of these and other factors is unfortunately often used as an excuse to take little or no interest in nuclear matters. But predictions can be made and farmers and others should ask questions and become aware of the likely effects of a nuclear war on their own particular farming enterprises and the problems that they would have to face. For example, if you have a dairy herd, and you have to stay in shelter for two weeks or more, how will the cows be fed, watered and milked? In this way the remote complexity of nuclear matters gradually becomes more understandable, personal and urgent.

HOW MANY BOMBS WILL BE USED AGAINST BRITAIN?

The Home Office Training Manual for Scientific Advisors (1977) suggests that an attack on Great Britain's military and industrial targets would be in the order of 200 megatons. The British Medical Associations' *Inquiry into the Medical Effects of Nuclear War,* suggests that an additional 400 megatons (600 megatons in total) might be needed to ensure the destruction of cruise missiles when they are dispersed throughout the United Kingdom. Others believe that because Great Britain has a unique concentration of targets and because 200 megatons represents only 5% of the total Russian nuclear megatonnage, we could face levels of attack of over 1,000 megatons.

HOW DOES THIS COMPARE WITH WORLD WAR 2?

Many naively think that a nuclear attack would be, "much like the last war only with bigger bombs". How far this thinking is from the truth can be judged by the fact that just two one megaton nuclear bombs contain

almost all the explosive force delivered by all the Allied Forces in the Second World War, and more importantly, *those conventional bombs did not produce radiation.* In a nuclear war deadly poisonous radioactive fallout would be carried by wind and water to the far corners of the globe, and because it remains active for hundreds of thousands of years it will affect our descendents, if any, for the whole of that period. A further fundamental difference is that conventional bombs *do not create the catastrophic climatic changes of freezing temperatures and darker days* that can be expected after only a moderate nuclear exchange. (See section on Climatic Changes).

The bomb dropped on Hiroshima killed 120,000 people in the first year and with subsequent fatalities the death toll is now nearly 200,000. *A 1 megaton bomb is equal in explosive power to 80 Hirosima bombs.* The bomb dropped at Hiroshima represents less than a millionth part of the tonnage that is possible with present levels of world armament. In fact there are now stockpiled over 4 tonnes of T.N.T. equivalent for every man, woman and child on this planet. That means we could have the equivalent in destructive power of *the Second World War, every day for sixteen years.*

HOW MANY SURVIVORS MIGHT THERE BE?

Britain is a small island with a large number of military bases and strategically important industrial sites such as factories, fuel depots and nuclear power stations. This concentration of sites makes us more vulnerable to attack than any other nation. The level of attack that could be expected is at least 200 megatons, which according to the British Medical Association's estimate would result in 38.6 million people being killed and 4.3 million seriously injured.

Following a nuclear war most hospitals, blood supplies and drugs will have been destroyed; doctors, nurses and technicians killed or injured, and electricity, telephone and other public services put out of action. So most of the seriously injured plus all those with previously contracted illnesses, needing skilled medical attention, will die, leaving approximately 11 million initial survivors.

Public health and hygiene in wartime is always in danger of breaking down allowing disease to become endemic. Radiation would make this far worse because one of the ways it affects the body is to lower its resistance to all infection, making the young, the old and the weak particularly vulnerable. This would result in at least another million casualties and others would die later of radiation induced cancers. But the most pressing problem facing the survivors would be the lack of food. Depending on the time of year of the attack, summer/winter, pre or post harvest, another

2 to 6 million could be expected to die of starvation and exposure over the following two to three years. Thus out of an original population of 54 million (UK Census 1977) only about six million would survive. *We therefore hope that the information in these guides will be seen not so much as an aid to the 1 out of 9 who may survive but as a stimulus to the measures needed to prevent 8 out of 9 becoming victims.*

It now seems likely that planning a future for even this pathetically low number of survivors is optimistic as new research is now showing that just a moderate nuclear exchange will create such long term catastrophic climatic and ecological changes that even the Earth's fundamental bio-systems will be threatened.

Unbelievable as it may seem, the destruction of cities and the deaths of millions of people caused by the immediate heat, blast, and radiation could pale into insignificance compared to any one of these climatic or ecological effects. If they all occured then the population could conceivably be reduced to prehistoric levels, or below, and the extinction of the human species itself could not be excluded. (See next section).

CAN ANY SURVIVORS BE FED?

If there are any survivors one thing is certain, the more people that live, the less chance they have of finding enough food to survive. It would be unlikely that British Agriculture could feed more than 4–7 million people after a large scale nuclear exchange, even if it was spared the devastating climatic effects. Assistance would not be available from outside because the other food exporting countries of the West would also have been devastated. So even if civil defence procedures are improved to a position where everybody had access to a purpose built nuclear shelter, it would make little difference to the number of people who would survive in the long term.

Many people still think that, as in the last war, the countryside will be reasonably safe, and that farming, as we know it, will somehow continue. This is entirely wrong. Everyone not killed by blast, burns or immediate radiation exposure will be faced with catastrophic climatic changes and a drastically altered environment in which the survival of all living things will be threatened by starvation, disease, freezing temperatures and contamination with long lived radioactivity.

Any one of these effects would produce formidable problems for agriculture. Radiation, for example, cannot be detected by the human senses because it is odourless, colourless and tasteless. There is no effective antidote. Once you have inhaled or ingested radioactive particles, or been exposed to radiation, there is no way to neutralize that dose. It is not just mankind that will suffer; farm animals, farm crops, wildlife, birds, trees

and plants are all vulnerable to exposure and all can become contaminated and thereby endanger the rest of the food chain.

If and when it became possible to start farming again it would be found that there was little or no fuel, and no prospect of imports, and that fertilizer, agrochemical and veterinary stocks would be limited to those the farmer had on hand, and that electricity supplies would have ceased due to the destruction of power stations and their transmission lines.

The most immediate problems would be felt by livestock farmers. The failure of the electricity supply will hit dairy farms, and stand-by generators can only be used until fuel runs out. It is unlikely that a large herd could be hand milked for ever and even if it was, what would happen to the milk? With no one to collect or distribute it there would be little point in keeping more than a few cows in milking condition to supply local needs.

The intensive livestock units reliant on external power supplies would grind to a halt. Heating and ventilation systems would cease, and a large proportion of the livestock would die. In the long term there would be no food for them anyway, as this would be required to feed the human survivors.

Without fertilizers, pesticides and weedkillers, and with only primitive means of cultivating and harvesting, the post attack UK yield of grain (assuming there were no climatic or ecological effects) would be down to about 0.8 million tons, sufficient for only 4 million people. The bulk of agricultural output would be reduced to subsistence foods such as cereals and potatoes, but all food could be radioactive, so each life-saving mouthful would have to be tested, or eaten in the hope that it was not contaminated.

There would be no food distribution system as we know it, and stocks of food and seeds in many areas would be inadequate. Starvation would be rife and survivors would have to move, if they could, to less contaminated areas to grow their own food and make their own clothes.

If farming did survive then it would be in a form reminiscent of the dark ages. But even farming in the dark ages needed the extensive expertise of blacksmiths, saddlers, wheelwrights, weavers, and tool makers, not to mention the draught animals to sustain it. It is feared that many survivors would perish before these basic skills were learnt anew.

SUMMARY

It is conventional wisdom among many political leaders and civil defence experts to believe that if a nuclear war took place there would be more

than enough survivors who would be able to pick themselves up and with determination, application and imagination re-establish a credible western style civilization. These dreams are ill-conceived because they do not take into account the long term repercussions of a nuclear war on agriculture.

We know that a nuclear exchange of even moderate proportions would so damage Nature's fragile ecological balance that the survival of civilization, in the northern hemisphere at least, would be impossible. We should therefore abandon any delusion that the rural areas will be safe. In the event of a nuclear war agriculture would be devastated, and farming as we know it would not survive. Human survivors, if any, would return to the dark ages and their lives would be nasty, brutish and short. Even if, by some miracle, a few people escaped the heat, blast, radiation, the climatic changes, disease and starvation, the best that they could hope for would be to establish some method of subsistence farming and raise a family before they also met an untimely death induced by the radio-activity that will pollute the world for up to a quarter of a million years.

HEAT, BLAST AND CLIMATIC CHANGES

When a nuclear bomb is exploded it gives off an immense amount of energy of which 50% is blast, 33% heat, and 17% radiation. (Nuclear radiation is discussed in the next section). This section is divided into immediate effects, Heat (Light Flash), and blast and the longer term Climatic and Ecological Changes, including freezing temperatures, darker days, disruption of photosynthesis, altered weather patterns and an increase in ultra violet light.

From the farmers point of view it should be remembered that these are somewhat artificial distinctions as the effects would overlap and could be experienced in various combinations and intensities, so that in many areas the practical consequences of each would be inseparable. For example, blast and fire damage will reduce the effectiveness of many radiation precautions, and fear of radiation exposure will severely restrict the amount of outside work done by farmers, such as salvaging crops, tending sick animals, repairing blast damaged buildings, and felling timber to maintain fires essential for light and warmth in the dark and freezing conditions.

IMMEDIATE EFFECTS

HEAT

The centre of a nuclear explosion reaches a temperature of 20,000°C which is as hot as the sun. A one megaton weapon, air burst on a clear day, would destroy the skin of any person or animal exposed to the fire ball for up to a distance of seven miles, and the main fire zone would extend for a radius of eight miles. It is estimated[1] that 50%–100% of exposed farm animals in an area of 67,000 acres (27,000 hectares) would die from suffocation and burns.

Secondary fires would be started away from the main fire zone, these would arise partly from the heat wave setting fire to the inflammable materials such as hay and straw and partly from damage to installations such as heaters, electrical equipment and gas pipes. If a full scale attack on Great Britain was to be made at harvest time, over 70% of the corn crop would be lost from fire damage alone, more than the combined losses due to blast and radiation. Livestock losses would be serious, and it has

been estimated[2] that 28% of dairy cows, 12% of beef cattle, and 5% of sheep would perish as a result of fire and direct heat from the explosion.

The majority of the immediate fire deaths, human and animal, would be due to lung damage and the toxic effects of the inhalation of smoke, especially burning plastic. In a situation where firestorms are created, even those sheltering in undamaged cellars or purpose built shelters will suffocate because the fire would burn up all the available oxygen.

LIGHT FLASH

When a nuclear weapon explodes it produces an intense light flash. If humans or animals look up at the light produced by a one megaton explosion, from as far away as 32 miles on a clear day (57 miles on a clear night) it can burn the retina of the eye and cause permanent blindness. Even those not focusing on the light source, if they were within 13 miles of this explosion, on a clear day would be affected by flash blindness which would last for several minutes.[3]

BLAST

Rapidly expanding gases at the point of detonation give rise to a shock wave that travels from the centre of the explosion at supersonic speeds. At the centre of a large explosion winds can reach speeds of up to 2,000 miles per hour.

The human body is relatively resistant to the direct effects of blast but the very high overpressures caused by a nuclear explosion create potentially fatal effects such as rupture and haemorrhage of the lungs, air embolism and rupture of the gut and ear drums. As people and intensive livestock spend much of their time in or around buildings, most of the huge numbers of casualties from blast would be caused by the effects of collapsing buildings, and flying projectiles, rather than the direct result of overpressure. In areas where buildings were almost completely demolished there would be little chance of survival; in areas where damage was less there would still be a serious risk of injury and death from falling masonry, flying glass and other debris and, in the open fields and yards, of being dashed to the ground by the high winds.

It is estimated that blast and associated damage, from a one megaton weapon would kill 50%–100% of farm animals in an area of over 800 acres (324 hectares) and it could cause deafness in animals and man several miles from the explosion.

A ground burst one megaton explosion can excavate a crater 300 feet deep and 1,200 feet in diameter, blasting out 10 million tons of rock and

soil.[4] This type of explosion would be used to destroy missile silos and command bunkers. If the weapon was detonated above gound level a less deep but wider crater would be formed up to 30 acres in extent. It is estimated that 100,000 tons of rock and soil would be vaporised and the total debris lifted high into the atmosphere and beyond could amount to around 300,000 tons. Radioactivity from the weapon condenses on to this debris and it descends as particles to cover a wide area with lethal fallout dust. (See *Nuclear Radiation*).

Attacks on ports and naval installations would mean that some weapons would be exploded in the sea. This would create huge tidal waves, flooding low lying fields near to the coast and river estuaries. The water blasted up into the air would become radioactive and rain down over a wide area causing serious contamination. In a test explosion at Bikini atoll in 1946, a small nuclear bomb (20 kiloton) displaced a million tons of water, and produced tidal waves up to 94 feet high, 1,000 feet away; while at 4 miles they were still up to 6 feet high. Modern nuclear weapons are from 5 to 750 times more powerful, and in some estuaries the "bore" effect would increase the flooding still further.[5]

Distance in Miles from Explosions	*Peak Wind Velocity m.p.h.*	*EFFECTS*	*CASUALTIES*
0–2.5	320	Most buildings, except some reinforced concrete structures, levelled.	98% dead, 2% injured
2.5–4.3	160	Lightly constructed commercial buildings and typical houses destroyed; cracks and instability in heavier structures.	50% dead, 40% injured
4.3–8.0	95	Walls of typical steel-framed buildings blown away; severe damage to dwelling houses.	5% dead, 45% injured
8.0–13.0	35	Damage to most structures; windows blown in; considerable risk of injury from flying glass.	25% injured

Blast effects of a one megaton airburst nuclear weapon.[6]

LONGER TERM EFFECTS

HEAT AND BLAST

Fire and blast will also have serious long term effects on crop and livestock production. After the attack warehouses, factories, fuel depots, oil wells and water and electricity supplies will all be damaged, destroyed

or put out of action in one way or another, halting the production of machinery and all other products used on farms. Having no fuel (after farm stocks ran out) and no electricity, would mean that all motorised machinery would stop. Cultivation, sowing, harvesting, grain drying and transporting would have to be done by hand, or with the help of horses and oxen. Without fetilizers, it has been estimated that crop yields would drop by 50%. Also there would be no pesticides, fungicides and weed-killers. Without electricity for ventilation and fuel for the production and delivery of animal feeds, intensive livestock units would be wiped out, and all remaining livestock would have to survive without veterinary services and drugs.

CLIMATIC CHANGES AND ECOLOGICAL EFFECTS DUE TO SMOKE AND SOOT CLOUDS

It is impossible to say which of the many effects of a nuclear weapon explosion will be the worst. For overwhelming power the most awesome would be the fire ball; for long term insidious effects it would be nuclear radiation; but for widespread catastrophic damage to the delicate ecology of the natural world, new research is showing that the disastrous climatic changes discussed in the following paragraphs will have by far the most serious and widespread repercussions for all living things.

The findings of a massive two year study by a team of leading atmospheric scientists[7] are now predicting that a nuclear war will trigger catastrophic climatic and ecological changes. Incredible as it may seem, it is now thought that these changes will be more damaging than the combined effects of the immediate blast, heat and radiation. This new research has totally destroyed the concept of surviving a nuclear war and it has shown just how perilously close man is to destroying the delicate ecological balance upon which human life depends. Even more alarming was the finding that the use of only 1% of the worlds nuclear arsenal (100 megatons) on one hundred major cities, could trigger climatic changes nearly as severe as those caused by a 5,000 megaton nuclear exchange.

Heat would set fire to all the inflammable material in the targeted areas, this in turn would create secondary fires on a large scale in forests, woodlands, hedgerows, grasslands and crops. The degree of fire damage being dependent upon the weather conditions and the season at the time of the attack.

After a full scale exchange forest fires alone could destroy 400,000 square miles in the northern hemisphere, equivalent to the combined area of Sweden, Norway and Denmark.[8] There will also be much similar material hurled up from burning oil wells, gas wells, petroleum refineries and depots as well as from urban and industrial areas with their large

amounts of plastic and other petrol based products. These fires could last for weeks releasing as much as 200 million tons of soot and smoke into the atmosphere in a very short period.

All this fine carbon debris, together with dust from the explosion, would be thrown into the atmosphere and beyond, creating dark clouds that will markedly reduce the sunlight reaching Earth. This would create a *"Nuclear Winter"* with the following catastrophic effects:– Freezing Temperatures, Darker Days, The Disruption of Photosynthesis and Altered Weather Patterns.

Freezing Temperatures: Limiting the amount of sunlight reaching Earth will cause a dramatic fall in temperature. Within three to four weeks all areas except the coastal strips could experience temperatures of $-23^{\circ}C$ and the temperature would remain below freezing for 70 days after a 100 megaton exchange; for 90 days after a 5,000 megaton exchange; and 170 days after a 10,000 megaton exchange. All fresh water would be frozen and the ground frozen to a depth of one to two metres. After an exchange of 5,000 megatons or more it would be about a year before temperatures returned to normal.

All farmers are familiar with the problems created by a period of severe weather but in the "Nuclear Winter" temperatures below freezing could last nearly six months. These freezing conditions will occur independent of season and they could turn summer into winter. If the attack was in the spring then two natural winters would be joined into a continuous period of winter weather lasting for over a year and a half.

The most catastrophic effect of the cold would be the loss of plant growth. The impact of dramatically reduced temperatures on plants is dependent on the time of year they occur and the tolerance limits of the plant. The abrupt onset of cold is particularly important because it is unlikely that even cold tolerant plants could harden before lethal temperatures were reached. Winter wheat, for example, can tolerate temperatures as low as minus $15^{\circ}C$–$20^{\circ}C$ when preconditioned to the cold (as in winter) but the same plant may be killed by minus $5^{\circ}C$ if exposed during active summer growth. Only if the attack was in the autumn, when the six months effects would coincide with the northern winter, would there be any hope of crop survival. An attack at any other time would result in the total loss of the harvest, over the whole of the northern hemisphere, an event unprecedented in the history of man. But not only man would suffer, without protection from farm buildings and the provision of stored food, most farm animals would be unable to survive these prolonged conditions, the new born, the young, the sick, and the old would be certain to perish.

Darker Days: The severity of the light decrease (and temperature drop) due to the dark clouds obscuring the sun, will depend upon the volume and size of the dust and carbon particles that are forced up into the sky; together with the height they reach and the length of time they remain before they settle out, or are washed out of the atmosphere.

After a 10,000 megaton exchange 90% of sunlight would be blocked out for about six weeks and extended twilight would last for a further twenty weeks and normal light levels would not be restored for over a year. At lower levels of attack it would not be so dark but light levels would still be reduced over the whole of the northern hemisphere, for nearly a year.

This long *"Nuclear Night"* of reduced light, freezing temperatures and, in places, violent storms and heavy snowfalls, coupled with the damage and injuries from heat, blast and radiation, will cause enormous psychological stress and create appalling living conditions. Only humans and livestock in the most sheltered areas would have any chance of survival.

Disruption of photosynthesis: Sunlight is the only source of energy that plants can utilize to synthesise the materials required for growth and maintenance. If it is too dark, plants will not grow even if the temperature is maintained artificially. At the light levels expected after a substantial nuclear exchange plant photosynthesis would be severely disrupted, even halted for a time. At lower levels of attack, the reduced light levels would impair photosynthesis and although plants could probably maintain themselves, they would show less growth and production than at normal light levels. This would seriously reduce if not eliminate, all fodder for farm livestock and the much needed post-attack harvest for humans.

Altered weather patterns: The very cold land mass next to the warmer seas will create a large temperature gradient that will produce violent storms, particularly in the coastal strips, and heavy falls of snow further inland, even in summer.

Longer term weather patterns that depend upon sea currents and global air circulation could also be disrupted. The dark clouds and lower temperatures will influence these currents and circulation in much the same way as volcanic dust alters weather patterns. So even after the freezing temperatures and dark days have passed away it could take months or years for normal weather patterns to be resumed, causing further disruption to plant growth and crop production and creating serious problems for farmers and their livestock.

Increase in Ultra Violet Light: As the dark clouds clear, the *"Nuclear Day"* will dawn and yet another disaster could unfold. Large atmospheric nuclear explosions produce enormous quantities of oxides of nitrogen and these would react with, and destroy, the ozone layer in the stratosphere, allowing a two or three fold increase in the ultra violet light reaching the Earth. If this happened there would be several catastrophic effects; plant growth and crop yields would be seriously reduced; pollination by insects would be disrupted; and people and animals would be unable to stay outdoors for more than a few minutes without risking blindness and lethal sunburn. Animals and birds with fur and feather may escape effects of sunburn, but their eyes will have no protection and without sight, animals could not be expected to survive for more than a week or two. Humans could wear protective clothing and dark glasses but as this *"Nuclear Summer"* could last for several years, it would almost certainly seal the fate of those, if any, who survived the radiation and the freezing temperatures of the "Nuclear Winter".

Worldwide Effects: The combatant countries would not be the only ones affected in these appalling climatic and ecological changes. After a large scale nuclear exchange (10,000 megatons) in the northern hemisphere, the southern hemisphere would suffer three months of freezing temperatures followed by a period of weather much cooler than normal. Even after a small nuclear exchange the climatic changes in the North will alter the South's weather patterns and disrupt its agriculture. This, coupled with the loss of imports of food and specialist agricultural goods from the once prosperous North, would create serious food shortage and famine all over the world.

SUMMARY

For some time much has been known about the immediate damage caused by nuclear explosions, the blast, the heat, and the radiation, but only recently has research shown how a nuclear war would affect the environment. The reluctance on the part of Government to conduct this essential basic research stems from the experience of conventional warfare where weapons are relatively small and only superficially damaging. Steeped in this tradition, Military and Government have channelled large amounts of money and effort into the research and development of nuclear weapons, totally disregarding their major environmental effects. We now know that if nuclear weapons are used in any numbers then they will cause damage that goes far beyond the destruction of cities and the killing and maiming of millions of people. The survivors, if any,—will have to live in a world polluted with radioactivity for thousands of years, where many species will have perished in the "Nuclear Winter" or the "Nuclear

Summer", and where all survivors, animal and human, will run a great risk of contracting cancer and of exhibiting long term genetic damage. So when Governments and Civil Defence personnel talk about ways of dealing with the immediate effects of blast and heat damage don't be misled into thinking that these will be the only effects of a nuclear disaster.

NUCLEAR RADIATION

The immediate effects of a nuclear disaster will be so catastrophic that it may be thought that subsequent effects, in comparison, may seem almost trivial. Nothing could be further from the truth. Everyone not killed by blast, burns or immediate radiation exposure will be faced with a drastically altered environment. The survival of all living creatures will be threatened not only by catastrophic climatic changes brought about by clouds of soot and smoke obscuring the sun, but also by exposure to the insidious effects of long lived radiation that will contaminate the biological food chain for thousands of years.

When radiation passes through you it cannot be felt, seen, heard, tasted or smelt and as there is no safe dose for exposure to radiation we are totally dependent upon instruments for its detection and measurement. After a nuclear explosion it would be essential to test the environment with radiation meters to see if it was safe to emerge from shelter. All food and water, for both humans and farm animals, would also have to be tested to make sure that it was safe to eat.

WHAT IS NUCLEAR RADIATION?

A number of substances are radioactive, some occur naturally and others are man made. They are all unstable and give off radiation energy in the form of rays or particles. The following types of radiation are the most relevant:—

Alpha radiation—alpha particles have low penetrating power and cannot get through an open wound. However if anything emitting alpha radiation is eaten, drunk or inhaled, then it becomes very dangerous, producing ten times the damage of beta particles or gamma rays.

Beta radiation—beta particles have more penetrating power than alpha particles, they can penetrate 10 feet of air and .12 inches of water, wood or body tissue. They deposit their energy in a smaller area than gamma rays and are relatively more destructive, causing beta burns on exposed skin and vegetable tissue.

Gamma radiation—gamma rays can penetrate one metre of concrete so they can easily penetrate the human body. Hence heavy shielding is needed to protect living organisms.

MEASUREMENTS OF RADIATION

RADIATION DECAY

As radioactive substances give off radiation they change and become more stable. This process is known as *radioactive decay*. The *half-life* is the time taken for half the material originally present to decay and therefore the amount of radiation given off will also be halved. Radioactive elements have varying decay rates, examples are given below.

Name of Substance	Length of half-life
Rhodium–106	30 seconds
Iodine–131	3 days
Hydrogen–3 (Tritium)	12 years
Strontium–90	28 years
Caesium–137	30 years
Plutonium–239	24,000 years
Uranium–233	162,000 years

Before radioactive elements are considered to give off "safe" levels of radiation, ten half-lives need to elapse. (Some say twenty half lives). Thus it will take *at least 240,000 years* before the Plutonium, produced in nuclear power stations, is considered not to be dangerous.

MEASUREMENTS OF EXPOSURE TO RADIATION

The amount of radiation living things are subjected to is measured in *rads*, and the amount of biological damage done by that radiation is measured in *rems;* these two measures are needed because some radiation is more damaging than others. For example, the damage done by one rad of alpha radiation is about the same as that done by twenty rads of either beta or gamma radiation. The measurement of the amount of radiation absorbed by a person or animal is given in terms of a *dose rate*–that is so many rads per hour, day or year. The total dose received by a person exposed to radiation is called the *accumulated dose* and it is obtained by multiplying the dose rate by the time of exposure, making allowance for the fact that dose rates decrease with time because of radioactive decay. If for instance, we are told that the dose rate at one hour after a nuclear explosion is 100 rads/hour, the dose rate at 30 minutes after that explosion would have been much greater. In fact, in this case, the accumulated dose during the first hour would have been 520 rads, a dose that will kill well over half the men, women and children exposed.

So the dose rate, measured by radiation meter, does not reveal the severity of exposure and in a survival situation it would be vitally important not to confuse this reading with the accumulated dose figure.

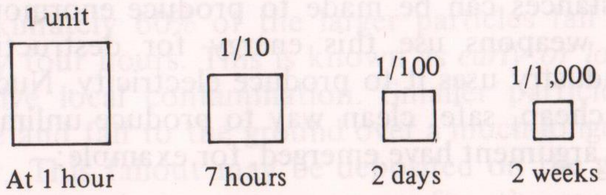
Radiation meters, or dosimeters have already been issued to Civil Defence personnel who have been trained to use them. They may also be purchased for individual use and cost about £150.

The standard measurement of radiation fatalities is given as the dose that will kill, within a few weeks, fifty per cent of those exposed. This is called the *Lethal Dose 50* or L.D. 50. For young fit adults the L.D. 50 is approximately 450 rads. Children because they are smaller, and the sick and elderly because their rate of cell repair is slower, are more vulnerable and the L.D. 50 for these groups would be lower.

The time over which exposure takes place also alters the L.D. 50 figure. It is more dangerous to absorb a large dose in a short period rather than smaller doses over a longer period, even though they may total more than the larger dose.

The Seven-tenths rule

The intensity of radioactivity in fallout declines with time. The rate of decay is rapid at first but it slows down as the short lived radioactive elements disappear leaving those that are longer lived. A formula has been produced by the Home Office for the time between one hour after detonation, up to about one hundred days, to express the average rate of decay of the products of the weapon. This is known as the seven-tenths rule and it enables one to make a quick, approximate calculation of the radiation level at any one time (within the 100 day limit).[1] Thus at 7 hours the radioactivity is 1/10 of that at 1 hour, at 49 hours it is 1/100 of that at 1 hour and so on. For example, an area showing 500 rads/hour at one hour after an explosion, should be down to ½ rad/hour (or 6 rads/12 hour day) after two weeks.



The 'Inverse Square' Law

The intensity of radiation received by a man, or animal, exposed to a single point source of radiation decreases rapidly the further away they are from that source. For example, if the distance is doubled the dose received will be a quarter of its previous strength. Hence it will be advisable to shelter in the middle of a room, farthest away from the radiation outside. *Home Defence and the Farmer* (H.M.S.O. 1958) states that "If you could keep 12 feet or so away from the nearest fallout

you would receive only about 2/3 of the radiation you would otherwise get"; but it should be noted if you are outside, fallout will be everywhere and, in practice it will not be possible to distance yourself from the radiation.

SOURCES OF RADIATION

NATURAL RADIATION

On average this amounts to 0.1 rem per year, but it does vary from place to place. Natural radiation is sometimes called background radiation, and this often includes man made radiation, which consists of the radioactive emissions from power stations, and the long lived radioactive products released into the atmosphere by the nuclear weapon tests in the 1950's.

RADIATION USED IN MEDICINE

This includes X rays used for diagnosis and gamma and X rays used in the treatment of cancer. As it is now generally accepted that there is no safe level of radiation exposure, X rays are only used in cases where the benefits to health are thought to outweigh the risks. For example, pregnant mothers are very rarely X rayed in the first three months of pregnancy because a higher incidence of cancer has been found in children whose mothers were X rayed in this period.[2] A chest X ray entails a dose of approximately .01 rem and it is now thought that some mass X ray screening programmes may have caused as much illness as they detected. X rays are not nuclear radiation but they are included here because they damage living cells in the same way as nuclear radiation.

RADIATION AND THE NUCLEAR POWER INDUSTRY

Radioactive substances can be made to produce enormous quantities of energy. Nuclear weapons use this energy for destruction, whilst the nuclear power industry uses it to produce electricity. Nuclear power was introduced as a cheap, safe, clean way to produce unlimited electricity. But errors in this argument have emerged, for example:—

1. The nuclear power industry continuously produces waste with high, intermediate and low levels of radioactive contamination that have a short, medium or long-lived duration. The high level, long lived waste poses a particular problem because it will be dangerous for at least 240,000 years, and as yet no decisions have been made on where to store it or how to stop it leaking into the environment.
2. Accidents are another cause for concern, statistically the chances of an accident are very low but as the consequences of a major accident would be appalling, so the risks are very high indeed.

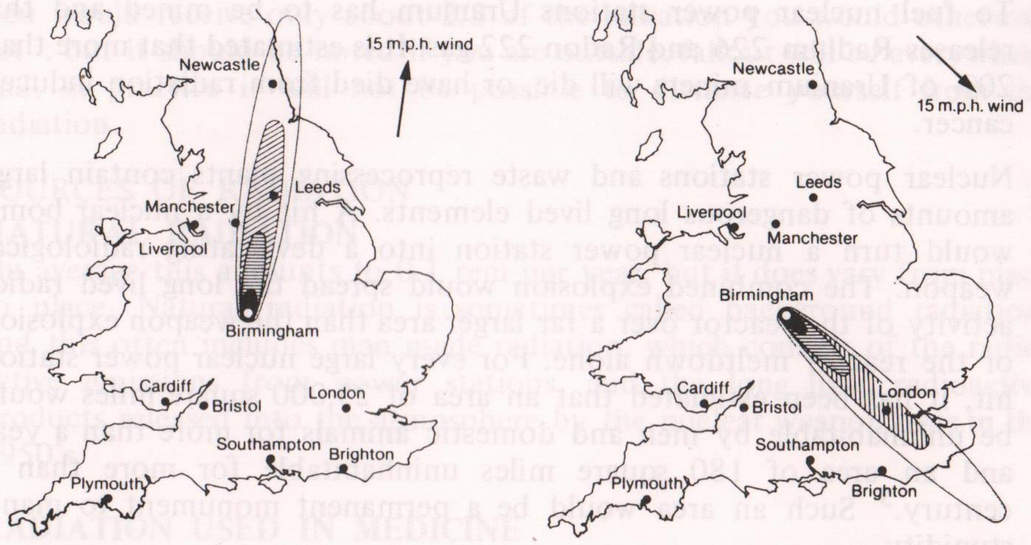
3. To fuel nuclear power stations Uranium has to be mined and this releases Radium 226 and Radon 222 gas. It is estimated that more than 20% of Uranium miners will die, or have died from radiation induced cancer.
4. Nuclear power stations and waste reprocessing plants contain large amounts of dangerous long lived elements. A hit by a nuclear bomb would turn a nuclear power station into a devastating radiological weapon. The combined explosion would spread the long lived radioactivity of the reactor over a far larger area than the weapon explosion or the reactor meltdown alone. For every large nuclear power station hit, it has been estimated that an area of 25,000 square miles would be uninhabitable by men and domestic animals for more than a year and an area of 180 square miles uninhabitable for more than a century.[3] Such an area would be a permanent monument to man's stupidity.

RADIATION PRODUCED BY NUCLEAR WEAPONS

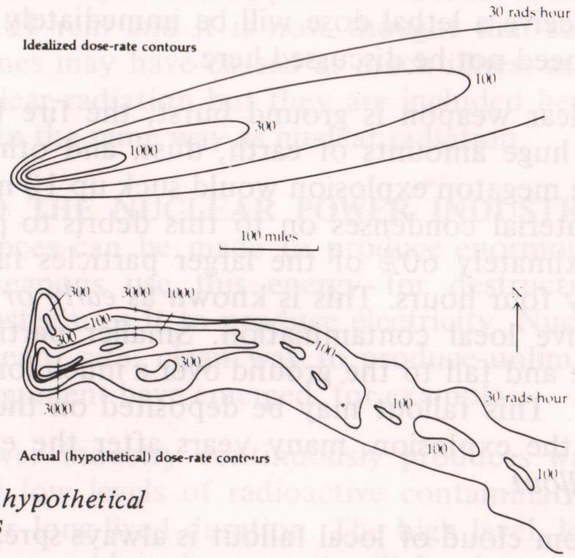
When a nuclear bomb is detonated one third of its energy is immediately released as *initial radiation,* but since people or animals near enough to the explosion to receive a lethal dose will be immediately killed by the blast and or heat, it need not be discussed here.

When a nuclear weapon is ground burst, the fire ball, and associated winds, lift up huge amounts of earth, dust, and other debris from the ground. (A one megaton explosion would suck up 10 million tons of soil). Radioactive material condenses on to this debris to produce *radioactive fallout.* Approximately 60% of the larger particles fall to the ground in the first twenty four hours. This is known as *early or local fallout* and it produces massive local contamination. Smaller particles rise high into the atmosphere and fall to the ground over a much longer period creating *delayed fallout.* This fallout may be deposited on the ground thousands of miles from the explosion, many years after the event and it is then called *global fallout.*

The mushroom cloud of local fallout is always spread down-wind from the point of explosion, in an elongated, roughly elliptical or cigar shaped area. The size and shape of this area, and the levels of contamination it contains *(dose rate contour pattern)* depends on a variety of factors—such as the size and type of weapon, height of explosion, type of soil, wind pattern, rainfall, and the lie of the land. Highly variable patterns are created with high and low spots of contamination.



Alternative patterns of fallout from a one-megaton ground burst on Birmingham depending on wind direction. The contours indicate seven-day accumulated doses of 3,000, 400, 100, 30 rads to unprotected people. A dose of 400 rads will kill about half those exposed to it.



Comparing idealised and hypothetical dose-rate fallout patterns

These maps will be drawn by Civil Defence personnel after the explosion and used to advise farmers of the estimated radiation levels in their area. However, if two or more bombs are exploded in an area, then overlapping effects will be created and it will be virtually impossible accurately to estimate the dose rate at any given position.

EXPOSURE TO RADIATION

EXTERNAL IRRADIATION

Fallout gives out radiation as it descends, is blown about, or when it settles on the ground, this gives rise to external irradiation in one of two ways. 1. By exposure to gamma rays that irradiate from a distance or after they have settled on the clothing, hair or skin. And/or 2. By exposure to beta particles that cause serious burns *(Beta burns)* if they settle on the skin, or in the mouth, nose or eyes. Protective clothing offers no protection against gamma radiation; it may however prevent radioactive fallout from getting onto the skin or into the body.

INTERNAL IRRADIATION

This occurs when radioactive particles are inhaled, ingested, or get into cuts or breaks in the skin. Particles may be ingested in several ways–

a By drinking water or any other liquid contaminated with radioactive fallout.
b By eating food contaminated by radioactive fallout.
c By eating crops that have taken up radioactive particles as they grow.
d By eating meat or drinking milk from an animal that has ingested radioactive particles from its own food and water.

RADIATION EFFECTS ON HUMANS AND ANIMALS

When radiation passes through living tissue it damages or destroys the tissue cells. Cells that divide rapidly, those found in the mouth, nose, lungs, bone marrow, and digestive system, are the most vulnerable; hence the symptoms of radiation sickness are, internal haemorrhages, vomiting and diarrhoea. The type and severity of the symptoms experienced is determined by the number and type of cells that are affected and the rate at which the body can repair them, if too many cells are affected then death will ensue.

Sometimes damaged cells remain alive but are not repaired, these may then go on to produce cancer or in the case of reproductive cells, genetic damage.

It has been estimated that, for every 100 rads to which their parents were exposed, 2,000 children out of every million born could be genetically defective. And an exposure of 300 rads would mean that just about everybody would get cancer of one form or another.[4]

Body defences are designed to repair and replace damaged cells, so given time and care, recovery from some facets of low level exposure can occur. In an emergency, Civil Defence personnel will make the assumption[5] that human beings could recover from a dose of about 10 rads/day for up to 100 days, but this is strongly contested by many radiation experts (see levels of exposure).

The table below describes the symptoms of radiation sickness, and gives the expected proportion of deaths in the short term. Those who survive should not consider that they are unaffected as radiation exposure will, in the longer term, give rise to a higher incidence of cancer including leukaemia, and deaths from other diseases will increase because radiation exposure lowers the body's resistance to all infections.

Dose (rads)	Progress of radiation sickness and length of time each stage takes			No. of deaths and cause
0–100	Men temporarily become sterile above 20 rads			0
100–200	Nausea & vomiting Less than one day	No symptoms Two weeks	Nausea & Vomiting. Less resistance to infection Four weeks	0
200–600	Nausea and vomiting. 1–2 days	No symptoms 1–4 weeks	Nausea, vomiting and diarrhoea. Blood blisters on skin. Internal bleeding. Resistance to infection low, so infections are a problem. Up to 8 weeks	0-98% from internal bleeding/ infection.
600–1,000	Nausea and vomiting 2 days	No symptoms 5–10 days	Same as for 200–600 rads 1–4 weeks	98-100% from internal bleeding /infection.
1,000–5,000	Nausea and vomiting Less than 1 day	No symptoms 7 days	Nausea, vomiting and diarrhoea. Salt balance in blood disturbed. Infection & fever. Internal bleeding 2–14 days	100% from collapse of circulation, infection & starvation.
more than 5,000	Nausea and vomiting followed immediately by convulsions, loss of control of movement and lethargy.			100%within 48 hrs from breathing failure or brain damage.

WILL PRECAUTIONS BE EFFECTIVE?

It can be seen that extreme care has to be taken to avoid as much fallout as possible. If you do have to go out, wear fully protective clothing with a dust mask and goggles and block the ears with cotton wool. When you return to the shelter, wash down and remove all clothing that may be

contaminated in such a way as to ensure that as little fallout as possible gets into the shelter. Take great care not to drink contaminated water. If possible wash with clean water all food that may be contaminated, and do not eat meat or drink milk from any animal that may have eaten contaminated food.

Above all else, before the explosion, build a suitable shelter in the middle of the house and stay in it until it is safe to come out. In some areas that will be months rather than weeks. The thicker the wall of the shelter the safer you will be, for example, 10″ of earth, or 9″ of brickwork, or 7″ of concrete will reduce the dose rate to about 1/10th of the original. The protection afforded by a building against penetrating gamma radiation is expressed as the *protection factor* (PF). The actual protection factor will depend on the type of building and its construction, the floor level, and the proximity of other buildings. The average room will have a protection factor of 5, and if it is not destroyed by blast or heat, you will receive 1/5th of the dose you would have received if you had stayed out in the open. Cellars make the best shelters and some may have a protection factor of 50. But most basement rooms would need a considerable volume of earth piled against the outside walls and windows to offer a protection factor of more than 10. Farm buildings made of asbestos, wood or corrugated iron would help to keep fallout off livestock and fodder but they would not give much protection from penetrating gamma radiation and time spent in them would need to be classed as time outside. (See section *Farm Livestock*).

If you follow the above guide lines you will have more protection than if you ignore them, but don't be misled into thinking that you will be safe. In areas subject to heavy blast and fire damage and high radiation exposure these precautions will be useless. Even in areas of no blast and fire damage and low levels of radiation exposure, such precautions can never be totally effective. Survivors will be extremely fortunate to remain uncontaminated and as there is no safe dose of nuclear radiation exposure, they will certainly be at risk.

ARE THERE SAFE EXPOSURE LEVELS?

It is very important that everyone reading this booklet should make up their own mind as to the level of radiation exposure they would consider to be safe or acceptable. To contrast the difference between war time and peace time radiation doses some safety levels are listed below. (Watch for the difference between rads/hours, rads/day and rads/year.)

PEACE TIME

0.17 rads/year — Level set by the International Commision on Radiation Protection as the recommended maximum average dose

	to which the public should be exposed in addition to natural background, and medical radiation. This is the legal maximum exposure for the general public in the United States of America.
0.50 rads/year	Legal maximum exposure for the general public in United Kingdom.
5.00 rads/year	Legal exposure limit for adult nuclear workers.
10.0 rads/year	An area given this level of exposure would be evacuated after a nuclear accident.

WAR TIME

10 rads/working day (½ rad/hour)	When radiation levels are at this level the All Clear would be sounded. According to the Home Office booklet Protect and Survive, "The All Clear means that there is no longer any immediate danger from air attack and fallout and you may resume normal activities."
150 rads over 2 days	Maximum permissible *War Time Emergency Dose* (W.E.D.) for those engaged in vital work.
150 rads over one week	Maximum permissible W.E.D. for those engaged in essential work.
75 rads	Maximum permissible dose for all others. This could be one exposure or a cumulative total.
10 rads/day for 100 days max.	Considered, by the Home Office, to be an acceptable dose, in addition to the above doses, because it is assumed that the body has an equivalent recovery rate. (That is why the All Clear will be sounded at 10 rads/day.)

We should be extremely sceptical of these War Time Emergency Dose Figures as many radiation experts doubt their validity. The total of 150 rads plus 10 rads/day for 100 days would amount to an exposure of 1,150 rads over 100 days, there is no scientific evidence to suggest that this level of exposure would be "acceptable" or relatively harmless.

The Home Office encourages us to believe that at these levels of exposure (*Nuclear Weapons* H.M.S.O. page 12.) ". . . there will be no apparent radiation injury and no physical or mental deterioration of the individual." The point to remember is that what is meant by "no apparent injury" and "maximum permissable dose", is that if you accumulate that dose you will not get acute radiation sickness, nor will you die in the next few months. But the long term effects, *so often not taken into account by the Home Office*, mean that your chance of contracting cancer and many other diseases are much increased, so too it the likelihood of your future children and grandchildren having genetic defects.

So if essential workers like farmers and their staff expose themselves to these high levels of radiation, for the sake of their stock or other peoples food supplies, they do so in the certain knowledge that the length and quality of their own life will be seriously jeopardized.

Note: 10 rads per year (not per day) is the limit in an area before it is evacuated in peace time. One 10 megaton weapon could produce a dose near to this limit over an area that exceeds the land area of almost every European country.[6] (In a nuclear war the U.K. might receive an attack of 200 megatons).

RADIATION EFFECTS ON PLANTS

Radiation affects all living cells, and plant cells are affected in much the same way as animal cells; the higher the exposure the more severe the effects. As exposure increases plants become sick and stunted and will die. High levels of exposure will kill trees. Young plants are affected more than old, and species vary in their susceptibility, for example, conifers are more sensitive than decidious trees. Those plants and trees that are more resistant to radiation will survive, but it should be noted that paradoxically these are the ones that will eventually take up long lived radioactive particles from the soil, thus making their much needed crop poisonous to man and animal alike. (See section *Farm Crops*).

RADIATION EFFECTS ON WILDLIFE

As we have seen, radiation causes no pain when it penetrates the body and it cannot be detected by any of the other senses, so humans will require meters to detect its presence in the environment and in their own and their animals food. The country's wildlife will be tragically vulnerable in this situation, without shelter it will be exposed to the highest doses of fallout radiation and suffer accordingly.

THE LONG TERM EFFECTS OF RADIATION

The long term effects of radiation are not considered at all in readily available Government literature. According to *Nuclear Weapons* H.M.S.O. page 58, "This hazard should be discounted for home defence planning purposes." It is almost impossible to understand this deliberately misleading statement because everyone knows that survival, after a nuclear attack, means much more than just getting through the first one hundred days. The seven-tenths rule for radioactive decay is only a convenient approximation to cover the first one hundred days after a nuclear explosion. Although the short lived elements will have mostly decayed in that time, the longer lived elements remain and some will be active for over a ¼ million years.

These long lived particles will be spread around the world in global fallout and will be readily taken up by plants, via their roots, creating a long term ingestion hazard. Dust will also be a hazard. One millionth of a gram of plutonium–239, if inhaled, can cause fatal lung cancer and will, as the body decays or is cremated, return to the environment to be inhaled or ingested, time after time, with the same fatal effect. The atmospheric nuclear bomb tests in the 1950's released 5 tons of plutonium into the atmosphere committing, it is estimated, one million people in the northern hemisphere to plutonium induced lung cancer.[7]

The long term effects of polluting the whole of the biological food chain with these long lived isotopes has only just begun to be debated. Clearly, they have the potential of creating an ecological disaster which will create appalling problems for those who may survive.

SUMMARY
Farmers for a Nuclear Free Future believe that many of the measures suggested by Government in *Home Defence and the Farmer* (H.M.S.O. 1958) to combat or alleviate the effects of radiation are naive and falsely reassuring and they seriously underestimate the dangers and difficulties of maintaining even a subsistence agriculture in areas contaminated by fallout.

We feel it is most unfortunate that realistic survival figures and proper estimates of radioactive fallout and its duration (as well as information about the expected climatic changes) have not been disclosed by Governments or the Military and it has been left to groups of concerned scientists to inform the world and warn of the appalling risks the politicians are now taking with the planet.

FARM LIVESTOCK

All farm livestock will be severely affected by a nuclear disaster. Loss and injury can be caused in several ways, either directly to the living animal, to its sources of food and water, or by the inability of the farmer to feed his livestock. The ways in which this loss and injury could be inflicted are discussed under the heading, Heat, Blast, Radiation, and Climatic and Ecological Changes.

HEAT

Losses from burns will be largest in areas near to the centre of the explosion but further away secondary fires of combustible materials will increase the casualties. In a full scale attack it has been estimated[1] that 28% of dairy cows, 12% of beef cattle, and 5% of sheep will die from the effects of fire alone. Fuel depots will also be hit and it is expected that virtually all stocks of petrol and diesel fuel will be destroyed causing serious difficulties for livestock farmers, especially in the cultivation and harvesting of fodder.

BLAST

Blast will also kill by blowing humans and animals off their feet and dashing them to the ground. Flying debris from destroyed buildings and the collapse of buildings like cattle sheds and barns will further increase the death toll. Blast will also dislocate all main services and even if some power stations survive the attack, power lines will be blown down and the supply system destroyed. Without electricity and with damaged installations, it is unlikely that mains water supplies will be maintained.

Without fuel and power modern agriculture will rapidly come to a halt. The on farm stocks that remain undamaged will not last very long and there will be no expectation of fuel and food imports because the resources of other exporting countries will in all probability have also been destroyed. Tractors, farm machinery and electric milking machines would have to be abandoned and the organised marketing of farm animals and their produce would cease.

LIGHT FLASH

When a nuclear weapon explodes it produces an intense light flash. If, on a clear day humans or animals look up at this light, it will burn the retina of the eye and cause permanent blindness from as far away as 32 miles

from a one megaton explosion.[2] Even those not focussing on the light source, if they were within 13 miles of this explosion, would be affected by flash blindness which would last several minutes. This unexpected phenomenon would effect all animals and birds from domestic pets to wildlife.

EXPOSURE TO NUCLEAR RADIATION

Nuclear radiation is of three main types. Gamma rays that damage from a distance by external irradiation. Beta particles that damage by contact with the skin, mouth, lungs or gut, causing beta burns, and alpha particles that are very dangerous if eaten or inhaled.

All these radiations are dangerous to livestock and all are to be found in fallout. Fallout is made up of small particles of soil and debris that are contaminated by radioactivity and then blown high up into the air by the force of the explosion. Most of these particles soon descend covering a large area downwind of the explosion with a fine dust. To counter the disturbing fact that radioactivity by itself cannot be seen, smelt, felt or tasted, civil defence personnel make great play of the fact that this fallout dust can be seen and by inference, dealt with. This is deliberately misleading. After fallout dust has been blown around by the wind and washed in by the rain, it will be almost totally impossible to distinguish it from everyday dust or natural soil. As radioactivity cannot effectively be neutralized, the only real protection for all living things is to keep away from it until it decays. Depending on the type of radioactive element, this may take up to ¼ million years. Protection from beta and alpha radioactive particles is only achieved if all fallout if kept out of buildings, off the skin and out of food and water. Protection from gamma rays is more difficult, standard farm buildings will give little protection since deep sheltering is required to effectively block these rays.

Animals grazing in fields are most at risk because they will be completely exposed to radioactive fallout twenty-four hours a day. Fallout will land on the animals and lodge in their coat and it will also contaminate pastures. As animals lie down particles will get on their udders and genitals causing beta burns and as they graze it will be taken into their bodies. *Home Defence and the Farmer* H.M.S.O. 1958 says, "Trees would give some protection", but for all practical purposes, this advice is now thought to be naive and misleading.

Penned animals would be a little safer because they would not eat so much fallout. Civil defence officials suggest that animals could be penned

in deep farm lanes, and covered with a tarpaulin; in areas not subject to blast damage this would give some protection but only from alpha and beta radiation.

Housing in a sealed building so that fallout dust does not enter, and feeding with stored covered food and water, would offer stock the best chance of survival. The practical difficulties would however be enormous. It is unlikely that enough un-contaminated food and water could be stored and that feeding and mucking out and adequate ventilation could be achieved inside a sealed building.

Pigs are more resistant to radiation than cattle or sheep, and poultry are more resistant than pigs. But outdoor pigs will be exposed to a serious additional source of contamination, as they root in the ground they will ingest radiactive fallout that has lodged on or in the soil:

The following table gives an indication of the relative susceptibility of farm livestock in buildings[4] :–

Animal	*L.D. 50 Exposure dose. (Rads)*
Sheep	400
Cattle	500
Pigs	640
Horses	670
Poultry	900

Fallout that lands in the farm yard, on farm building roofs, in animal pens and on animals backs can be washed away. Remember that there will not be any piped water and so hosing down will not be that simple. If possible the backs of exposed animals should be washed as soon as possible after the initial fallout has stopped, to dislodge as much of it as possible from their coats. Beta particles are only damaging when in contact with the skin or internal membranes so their removal would nullify their danger. Great care should be taken in this operation, protective clothing should be worn and this should afterwards be washed off and then removed. Treatment of stock in this way may not be thought of as worth while, since the farmer and the stockman may not wish to jeopardize their own lives in order to treat animals whose lives may only be prolonged rather than saved.

The most serious damage will be in targeted areas. These will be sites of strategic importance, military bases, missile sites, fuel depots, power stations, factories etc. Farms next to these sites will be obliterated and nearby farms could not expect any assistance for at least two weeks after the attack as surviving doctors, nurses, veterinary surgeons, firemen and policemen have been instructed to stay out of highly contaminated areas and not risk their lives unnecessarily. Similarly, surviving farmers will either have to abandon their stock and stay in their shelter, if they have one, or conscientiously care for their stock and thereby risk almost certain death.

As we have seen, different species are killed at differing levels of radiation exposure. Death occurs within a few days at high levels of exposure, at lower levels several months of sickness can occur before death ensues. At even lower levels radiation sickness is experienced, but given time and adequate nursing some recovery is possible. At the lowest levels of exposure no visible damage is done, but as there is no safe dose of radiation, the animal will have been affected and in many of these cases, as well as the higher levels of exposure, cancers and genetic damage will have been initiated.

Radiation disrupts rapidly dividing cells, especially those lining the gut, the mouth, and in the blood, and so the main symptoms or radiation sickness in farm animals are–

Loss of appetite
Loss of weight and condition
Depression, apathy and irritability
Diarrhoea, sometimes bloody
Haemorrhages, e.g. bleeding in the mouth, small or diffuse haemorrhages in the skin, and internally, haemorrhages of various sizes in most organs.

Pregnant animals may abort and all exposed animals will be more susceptible to infections due to a lowered resistance caused by a fall in their white blood cell count. There is no treatment for animals suffering from radiation sickness.

After a full scale nuclear attack, the effects of radiation alone may kill about 20% of the nation's livestock. Other losses from burns and blast damage would add to this total and it would be increased still further by intensively housed livestock perishing through lack of power and food.

Even though the holocaust will have greatly reduced livestock numbers, there will be a need to reduce these still further because of shortages of basic foods such as cereals and root crops which will be needed for priority human consumption. The Ministry of Agriculture will appoint farm wardens who, if they survive, will each run units of 20 farms under

the supervision of an area officer[5] and they will decide which stock are to be kept, slaughtered or moved compulsorily to other areas for restocking. Preservation orders are likely to be placed on healthy female sheep and cattle, leading to a male only slaughter policy for these species.

It would be expedient to kill seriously affected animals before they lost too much condition. The flesh could be eaten fairly safely if care was taken in the butchering, but remember there will be no electricity and therefore no slaughterhouses and no cold stores. So unless the freezing weather conditions occur rapidly (preserving the meat) the immediate surplus could only be preserved with salt, supplies of which are likely to be inadequate.

Butchering. External gamma radiation damages cells and makes the animal ill but it does not render the meat inedible. But gamma, beta and alpha radiation in fallout that is eaten or inhaled will contaminate the carcase.

If the animal is slaughtered soon after contamination the muscles should be safe to eat because the radioactive particles will lodge in the gut and the lungs. Great care should therefore be taken in the butchering, all offal should be discarded and the hide should not be allowed to contaminate the flesh.

Breeding, sterility and genetic defects in farm livestock: Nuclear radiation affects the breeding of animals in several ways. Firstly if the testes and ovaries are exposed to any level of radiation some damage will occur to the sex cells and this will give rise to genetic defects in subsequent generations. These effects may not be produced until many years after the initial exposure and in generations far removed from the one that experienced the original exposure.

Nuclear radiation is also capable of producing deformities in the embryo as it develops so that abnormal deformed offspring are born. Often these are so seriously damaged that they do not go full term and are aborted.

Nuclear radiation may also so weaken or damage the female that she aborts her foetus and she may then become permanently or temporarily sterile.

If exposed to high levels of radiation the male will become infertile. This may last for a year or so after which, if he survives, his fertility is likely to recover.

After the attack stock farmers would have to wait and see which females came on heat and which males were fertile and then breed from them and ignore the possibility of genetic deformities.

It is suggested that the best breeding animals should have priority of protection but it is doubtful whether todays high performance animals

would be the type of stock required by a subsistence farming that had returned to the dark ages, where hardiness would be at a premium. In selecting stock it should be remembered that young fit breeding adults would be of most use and have the best chance of survival. A select number of milking cows, working horses and cattle and a few sheep and chickens should have priority in this selection procedure.

Pests: Flies, fleas and other insects are relatively resistant to radiation, their L.D. 50 lying between 2,000 and 100,000 rads, far higher than their natural predators. Their proliferation will hamper all attempts to establish a subsistence agriculture as well as presenting a serious threat to health and hygiene. Many diseases of animals and man are spread by fleas and other parasites and stock already weakened by radiation or blast injuries would become ideal hosts. With the unavailability of modern pesticides, due to the destruction of factories, control would be extremely difficult.

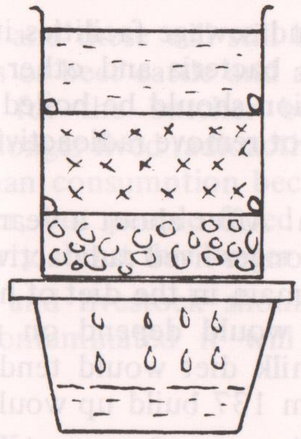
Rotting unburied corpses will provide a breeding ground for plagues of flies already benefiting from the lack of predators and pesticides. Blow flies in particular will thrive and maggot ridden animals will be commonplace.

The aftermath would present ideal conditions for the spread of rats, and again without modern methods of control they would become a serious health hazard.

Water: The provision of water, uncontaminated by radioactivity, would be essential for survival, but it would be very difficult to supply the needs of a large number of farm animals who could require up to 5 gallons (23 litres) a day each just for maintenance.

If there was enough warning of attack some provision could be made using small tanks (plastic bags in dustbins would be a good temporary measure) or small reservoirs could be dug out and lined and covered with plastic sheeting.

After the attack it is very unlikely that mains water will be running. All rivers and streams, and open reservoirs, in areas covered by fallout, will be contaminated. Farms with deep wells will be more fortunate, but without electricity and little fuel, some provision will have to be made to raise the water, taking care not to contaminate it with surface fallout. In areas with a high water table, wells can be dug and as the water seeps through to the well it will be effectively filtered. Otherwise water from fast flowing streams, the nearer the source the better, can be filtered through home made filters. These could be made from a bucket or five gallon drum with holes punched in the bottom, then filled with stones and earth covered by a porous cloth.



This could provide 2–4 pints (1–2 litres) of clean water per hour and will supply about 13 gallons (60 litres) before the filter gets blocked. The filter will collect radioactive particles so do not stand close to it and when it is being rebuilt remove the contents and bury them deeply, as quickly as possible. Take care not to contaminate the collecting vessel with this or any other material.

When radiation passes through water it does not make it radioactive. It is the particles that fall into it that create the danger and if these can be allowed to settle or be filtered out in some way then the water becomes much less contaminated. But a small fraction of radioactive contamination in and on fallout is soluble, so even filtered water will not be totally uncontaminated, but in the short term at least it should not incapacitate humans or livestock.

Water is vital to life and whether it is decided that water is safe or not will depend upon conditions at the time. One thing is certain, no effort can be too great to ensure the availability of adequate uncontaminated water and for that reason double precautions are advisable whenever possible.

In the first months after the attack, do not collect rain or snow to drink as this will contain dangerous radioactive particles gathered as it falls. Water collected off roofs will contain the fallout that has settled onto them. Shallow ponds or pools are likely to have fallout particles in suspension near the surface. Deeper pools and reservoirs are safer once the fallout has had time to settle to the bottom, but remove the water carefully and do not stir up the sediment.

The freezing temperatures that will accompany the expected climatic changes will make the provision of adequate uncontaminated water even more difficult, if not impossible. Fresh water would be frozen over, in some areas to a depth of one metre or more, so holes would have to be chipped in the ice before the water could be drawn up and the above precautions would still need to be observed.

With primitive medical and sewage facilities it is very likely that water will be contaminated with bacteria and other disease organisms, so all water for human consumption should be boiled or purified, but it should be noted that boiling does not remove radioactivity.

Long lived nuclear radiaton: After about a year the short lived radiation will have decayed but the longer lived radioactive elements like strontium 90 and caesium 137 will remain in the diet of humans and animals. Body burdens of these hazards would depend on many variables including the type of diet. A high milk diet would tend to lead to strontium 90 accumulation, and a caesium 137 build up would be especially noticeable in people eating a preponderance of meat. Another variable is the soil characteristics, for example, acid soils lead to much higher levels of caesium 137 accumulation in milk or meat.

EFFECTS ON MAJOR LIVESTOCK ENTERPRISES

MILK PRODUCTION

If milking cows are to be saved, the herdsman would have to shelter in the cattle yard with his stock and hand milk them. It is expected that even conscientious stockmen would choose to be with their families in this sort of crisis, milking would be abandoned and todays high yielding cows would quickly succumb to mastitis, and with no stockmen, vets or drugs, this would soon lead to septicaemia and death.

If any cows are hand milked then great care would need to be taken to ensure that radioactive fallout dust did not drop off the cow into the milking bucket. Without a supply of piped uncontaminated water it may prove to be difficult to wash down the cow adequately.

If cows eat or drink food contaminated with fallout, the radioactive particles will pass through their bodies and contaminate their milk. If either their calf or humans drink this milk they will, in turn, have this dangerous radioactivity in their bodies. Iodine 131 is particularly dangerous in this context. It has a rapid transfer into milk and if ingested it concentrates in the thyroid and causes cancer. Sodium iodate tablets if taken early enough block the uptake of Iodine 131 but as far as we are aware there are no plans to distribute these tablets so that animals can be protected in this way. Sodium iodate should not be thought of as a cure all, there are many other radioactive isotopes that will get into the body upon which it will have no effect.

If milk contaminated with fallout is made into cheese, the radioactivity will decline as the cheese matures, but it is likely to contain some long

lived radioactive isotopes and these will still be dangerous. Contaminated milk could be fed to pigs or beef cattle and although harmful in the long term they may be fit for the butcher before showing any serious symptoms. However the longer lived radioactive particles would make this meat dangerous for human consumption because it would increase their risk of contracting cancer, but people faced with the immediate threat of starvation may not worry about this longer term threat.

All food for humans and livestock should be tested with radiation meters, since if it is contaminated it will certainly cause damage if consumed.

INTENSIVE LIVESTOCK

Heat, blast, radiation, the loss of all main services and the unavailability of veterinary surgeons and their drugs, will cause enormous livestock losses. Virtually all intensive livestock will perish, even in areas of low blast and radiation damage. The dislocation of power supplies will mean that there would be no electrical ventilation, no automated feeding, no mills to produce the feeding stuff, and even if transport was available, no fuel would mean no deliveries. This means that large numbers of intensively reared pigs, chickens and calves will either have to be killed, left to starve to death of let out to roam free and pick up what food they can. The damage done by say, 10,000 pigs on the rampage would be enormous, so most probably the best course of action would be to kill them rather than let them starve to death. After the holocaust, it is unlikely that spare ammuniton will be available so if they were to be dispatched, probably clubbing would have to be resorted to.

With these large numbers of animals, and with little or no fuel for mechanical diggers subsequent burial will be virtually impossible.—Imagine a foot and mouth slaughter and disposal by hand !

In an area contaminated by radioactivity, disposal would certainly not be practical so the problems of disease, smell, rats, flies and other vermin coming from intensive livestock farms will be enormous. In all probability they would be abandoned, the farmer, the stockman and their families moving to other areas.

EGG PRODUCTION

It is advisable that, even in an emergency, at least a small part of the human diet should consist of animal protein, and eggs would be one of the most efficient ways of maintaining this input. It is thought that eggs from exposed but surviving poultry would probably not contain enough radioactivity to present a serious ingestion hazard as most radioactivity concentrates in the discarded eggshell.

But there are problems; as we have seen, intensive poultry units will be destroyed or abandoned. Battery hens do not readily become free range hens and their breeding is not ideal for the outdoor life. If the catastrophic climatic effects take place the hens will not lay in the cold and the dark even if they survive. Even if it were possible to establish a flock of free range hens it would take some time, genetic damage is bound to occur and without electricity artificial incubation is impracticable. they would also need guarding; a starving man will find it far more attractive to eat a breeding hen and her eggs than to look after her and her chicks for more than a year before obtaining food.

PIG PRODUCTION

Pigs are in direct competition with humans for most of their diet. As food would be in very short supply after a nuclear war, pig numbers would have to be severely restricted. Intensive pig units would be destroyed or inoperable, and so the few pigs that remain would have to run free range, scavenging a living as best they could, or be kept and fed on waste that humans found inedible.

Like grazing cattle and sheep, free range pigs would be exposed to fallout and to eating fallout that had settled on or entered into the plants they eat. In addtion, as they root around in the earth, pigs would ingest fallout from the soil.

BEEF PRODUCTION

Cattle at pasture will be exposed to fallout and they will take in an additional burden as they ingest fallout with the grass they graze. Winter fattening would not be possible as the cereals and other products normally used for this purpose will be diverted for human consumption. Some hardy cattle will roam less contaminated areas, but beef production will be low down on the priority list when and if agricultural production is restored.

SHEEP PRODUCTION

Sheep have a slight advantage over cattle in that their fleece would help to keep some fallout away from the skin thereby reducing slightly the extent of their beta burns, but as they eat they will be equally exposed to the fallout contaminating the grass.

Lambs have an advantage over steers, in that they can be fattened and slaughtered within a season and need not be overwintered. This short life could be advantageous in the animals could be fit for slaughter before disease, or cancer induced by radiation, had time to develop and weaken the animal.

With the catastrophic climatic changes producing freezing temperatures even in summer, upland sheep selected for their hardiness would have an

advantage. With much land becoming derelict, they would be at home on the rough grazing that will cover much of the country.

But the major advantage of sheep production would be the wool, after the attack, clothes would be in very short supply and wool for home spinning would be invaluable.

HORSES AND OTHER DRAUGHT ANIMALS

Of all livestock, horses would be the most useful to save and because of their present low numbers they should be given priority in sheltering facilities. Their value in supplementing manual work in a no fuel economy would be inestimable.

Manageable strong cattle could also be pressed into service as oxen, and their value should be remembered when selecting stock for priority sheltering.

Protecting horses and oxen from starving survivors may prove to be difficult.

VETERINARY AND OTHER SPECIALIST SERVICES

Veterinary surgeons would not be readily available after the attack because like all other professions many vets would be killed or injured and survivors would be instructed not to venture out until radiation levels are safe. When they did so, in all probability, their first call would be to supplement the medical services as casualty officers. After that it is unlikely that sufficient fuel would be available for the journey into the rural areas on a call-out basis, anyway how do you contact the vet, the doctor or the police when the phones are out of action and you have no transport. In the few areas where the vet overcomes these problems, he would arrive with no drugs, for antibiotics etc. would not be available after existing stocks ran out, simply because the factory that made them and the stores that supply them will have been destroyed or put out of action by power failure or lack of transport.

So all ill health and injuries, such as cuts, grazes, broken limbs due to blast damage and flying glass, blindness due to the light flash and radiation sickness will have to be dealt with as best they can, by the farmer and his staff.

All other specialist services would be similarly curtailed, there would be no A.I. service, no veterinary investigation laboratories and no feed, seed and soil testing facilities.

FARM WARDENS

At the onset of hostilities the Area Agriculture Officer and his Farm Wardens plan to take control of all farming production[6] and if they survive, they, together with Civil Defence personnel, will try to assess the

numbers of people and livestock that have survived the attack. They will then select a number of prime breeding animals for retention and if possible move them to areas of need, but with a starving population it will be difficult to ensure that breeding animals are not slaughtered for meat. Other animals like pigs that compete with humans for food would probably be culled. Farm Wardens would try to maintain a skeleton dairy herd in uncontaminated areas (if there were any) so that milk could be consumed on a local basis with priority for children.

SUMMARY
Farm livestock are not only a source of food they also compete with humans for scarce food resources so even those that manage to survive the heat, blast and radiation would have to be quickly reduced. Intensive livestock husbandry would be impossible. Remaining livestock would be restricted to: some sheep and cattle that could overwinter on rough grazing and provide meat and wool, free-range hens for egg production, a limited number of dairy cows to provide milk on a local basis especially for the young, and a few pigs to be fed on waste scraps. In the main however, meat would have to be replaced by grains in the human diet.

FARM CROPS

All farm crops will be severely affected by a nuclear disaster. Loss and damage can be caused in several ways, either to the growing plant or tree, to the stored harvest, or by the inability of the farmer to plant, harvest or tend to the growing crop. The ways in which this loss and injury could be inflicted is discussed under the headings, Heat, Blast, Radiation, and Climatic and Ecological Changes.

HEAT

All dry vegetation and inflammable material within a radius of four miles of a one megaton nuclear explosion would be burnt by the direct heat. Secondary fires would be started away from the main fire zone, these would arise partly from the heat setting fire to inflammable materials such as hay and straw and partly from damaged installations such as heaters, electrical equipment and gas pipes. If a full scale attack on Great Britain was to be made at harvest time it is estimated[1] that over 70% of the country's corn crops would be lost from fire damage alone, far more than the combined losses from blast and radiation. These secondary fires could devastate huge areas of forest, hedgerow, grassland and crops, the degree of damage being dependant upon the weather conditions and the season of the year at the time of the attack. *Forest fires alone could destroy 400,000 sq. miles in the Northern Hemisphere equivalent to the combined area of Sweden, Norway and Denmark.*[2] Destruction of plant growth on this scale would mean that vast areas of the soil would be exposed and subsequent erosion by wind or rainwater would destroy the chance of regeneration in many of these areas. (See also *Climatic Changes*).

BLAST

Blast would damage, flatten and destroy plants and trees up to about 10 miles from a one megaton explosion. However the most serious consequences of blast damage upon crop production will be the effect it has, together with fire, on warehouses, factories, fuel depots, oil wells and water and electricity supplies. All of these will be damaged, destroyed or put out of action in one way or another, halting production of all machinery and other products used on modern farms. Having no fuel (after farm stocks ran out) and no electricity, would mean that all

motorised farm machinery would stop. Cultivating, sowing, harvesting, grain drying and transporting would all have to be done by hand or with the help of horses and oxen. Without fertilizers it has been estimated that crop yields will drop by 50%. Insects, fungi, bacteria and weeds are all relatively resistant to radiation and blast damage so that without pesticides, fungicides and weedkillers they will thrive and crop yields will fall still further. Stored crops would fare no better, without insecticides and rodenticides, insects and rats, also relatively resistant to radiation, would be difficult to control and much stored food would be lost.

Attacks on ports and naval installations would mean that some weapons would be exploded in the sea. This would create huge tidal waves, flooding low lying fields near to the coast and river estuaries. The water blasted up into the air would become radioactive and rain down over a wide area causing serious contamination.

NUCLEAR RADIATION

Radiation affects all living cells, and plant cells are affected in much the same way as animal cells. The damage it causes to plants and agricultural crop production depends on the following factors:–

Severity of exposure
Stage of growth or age of the plant
Growing conditions after exposure.

Severity of exposure: When nuclear radiation passes through a plant or when fallout settles on a plant it damages or destroys the cells from which the plant is made up. The higher the dose of radiation that the plant is exposed to the more of its cells are destroyed and the plant becomes sick and stunted. If too many cells are destroyed the plant will die.

Most experimental work on plants has been carried out using gamma radiation (beta radiation being difficult to work with) but fallout emits alpha, beta and gamma radiation. It is known that beta radiation is at least as damaging as gamma radiation and in some circumstances it can be more damaging, especially for crops in the early growth stages when they have only minimal protective tissues. For example, it has been calculated[3] that if wheat seedlings are exposed to fallout they would receive a combined dose, of beta and gamma radiation, 20 to 40 times greater than the gamma dose alone. Therefore the published figures for gamma irradiation of plants are not applicable to fallout conditions. In this guide it is assumed that the combination of gamma and beta radiation in fallout will double the severity of plant exposure to gamma radiation alone (this is very likely to be an underestimate). When reading other literature check carefully the plant exposure figures, if they are for gamma radiation only then halve them, at least, to give an estimate of the plant's sensitivity to fallout.

Stage of growth: Cells that are rapidly dividing are the most vulnerable to radioactivity. So if a plant is exposed at the young growing shoot stage, or the flowering tip stage of growth, then crop yield will be severely affected. Seeds, because they are dormant or buried are less vulnerable but if exposed they may sustain genetic damage. (Hence the use of low doses of radiation for genetic manipulation).

Sensitivity to damage within a single species varies by fifty fold according to the age of the plant. So the time of the year at which an attack took place would have a decisive effect on crop losses caused by nuclear radiation. An attack in winter would result in the loss of winter sown wheat and barley seedlings, however it might be possible to re-drill three months later with spring varieties (if any seed escapes the destruction) and thereby produce a grain crop. Whereas an attack in spring when plants are young and vulnerable and there is no second chance to re-drill, could result in a total crop loss especially in areas of high contamination. High radiation levels could also mean that it would be impossible to plant or replant crops for fear of exposure of the farmer and his staff (See ploughing in fallout, page 49) this delay or abandonment of spring planting would have a dire effect on harvest yields. An attack in mid-season, as flowering tips or seed heads are developing, could also result in heavy yield losses although the plants may be left standing. An attack at harvest time would not effect the plant yield, but radiation levels might be too high for the crop to be harvested and delays at this time will result in the crop lodging or rotting. Thus an attack in August could result in the almost total loss of the grain harvest, and with grain stores traditionally low at that time of year the ability to feed the population until the following harvest, a full year later, could prove to be impossible. Similarly a reduced yield due to a spring attack could also result in insufficient food being available to feed survivors until the next harvest.

Growing conditions after exposure to radiation: At non-lethal levels of exposure the better the growing conditions, including weather, soil, plant nutrients and lack of competition, the more chance the plant has of recovery from radiation damage and reaching maturity in time to yield its crop, even if reduced, before the onset of winter.

Type of crop: It is known that plant species vary in their sensitivity to nuclear radiation exposure *by at least 100 fold.* As it is necessary to have some form of measurement of the damage done to plants by nuclear radiation, their sensitivity is normally measured as the lethal dose that kills 50% of the plants (L.D. 50). In the same way the sensitivity of the yield of the crop is normally measured as the dose that reduces the yield

by 50% (Y.D. 50), as an approximate rule the lethal dose for only 10% of the crop (L.D. 10) reduces the yield by 50% (Y.D. 50), hence L.D. 10 = Y.D. 50.

In general a total loss of the crop is to be expected when the radiation exposure is three or more times the Y.D. 50 for that crop, but it can occur when exposures are only 50% greater.[4]

A list of plants with their approximate Y.D. 50 to fallout exposure is given below, but remember that because age of plant and growing conditions are so important there is no such thing as an absolute value under field conditions. (Rad: radiation absorbed dose, is a measurement of radiation).

Broad Bean	50 to	150	Rads
Pea	125 to	500	,,
Barley	300 to	1,250	,,
Wheat	500 to	1,750	,,
Lettuce	2,000 to	2,500	,,
Sugar Beet	1,250 to	4,000	,,
Potatoes	1,000 to	4,500	,,
Tomato	2,500 to	5,000	,,
Rice	5,000 to	12,500	,,
Grasses	1,000 to	12,500	,,

The following examples, illustrating stages of growth, are given to emphasise the difficulty of giving an absolute value for the sensitivity of plants to nuclear radiation.

a If say a Barley crop is exposed to 1,000 rads at the seedling stage it would suffer a 50% plant loss (L.D. 50), the surviving plants would be damaged and the harvest yield would be devastated. If a similar crop is exposed to a similar dose later in the season then only 10% of the plants would be lost (L.D. 10) and others would be damaged resulting in a 50% reduction in yield (Y.D. 50), if a crop was exposed at harvest time there would be no reduction in yield but risk of radiation exposure to the harvesters would make it difficult or impossible to gather in the crop.

b Other crops, tomatoes for example, may be so retarded by exposure that although the plant survives, the crop is too late in the year to ripen resulting in a 100% loss of yield.

c The yield of legumes is most severely affected if the plant is exposed at flowering time, at which stage 50–200 rads will reduce yield by 50%. At other stages of growth it may take 100–3,000 rads to inflict the same damage.

d The viability of seed can be reduced by the irradiation of the parent plant or the mature seed when it is in storage after harvest. Irradiation of the parent plant has the most effect on progeny when it occurs before flower development. Seeds generally represent the most resistant stage of the plants life cycle and the L.D. 50 values of the common farm seeds and grains, when dry, range from approximately 5,000 to over 20,000 rads for exposure to fallout. Even so it would be wise to protect essential seeds from the effects of radiation and they should be stored in a deep, dry, earth covered bunker.

It has been estimated that a dose of 5,000 rads would devastate most vegetation apart from grasses and a dose of 2,500 rads would devastate most crops, and after a dose of 1,000 rads, cereal crops would be virtually useless. In a full scale attack on Great Britain it is estimated that crop losses from radiation alone would average about 16% and in some circumstances could be as high as 34%.[5]

It should be stressed that these are the best estimates that are currently available. In keeping with the Governments obvious wish to disregard the long term effect of a nuclear disaster, "Nuclear Weapons" H.M.S.O. 1982 states, "Reasonable assessment of the likely overall losses on the harvest following a nuclear attack cannot yet be made. Further research is needed." The proceedings of the symposium held at Brookhaven National Laboratory in America some twelve years earlier stated, "Clearly a much greater research effort is needed to fill the gaps in our radiobiological knowledge of economically important plant species." As farmers we ask, why is this basic knowledge about the effects of a nuclear disaster on crops still not available? Research and development of new nuclear weapons seems particularly foolhardy when their effects on our basic foodstuff is not completely understood.

Harvesting and the external contamination of crops: If fallout descends on growing crops it will adhere to their surfaces, particularly if damp, and get caught up between leaves, stalks and husks. This will not only damage the plant but also present a serious ingestion hazard to man and animal.

After a nuclear attack it should be assumed that all crops have fallout on them. Those with smooth surfaces or pods, such as apples or peas, should be shaken, wiped and peeled and the blemishes cut out. Those with rough surfaces, such as cabbages should have each leaf separately shaken and washed. Edible roots should be brushed and washed and peeled before they are cooked. Cereals should be winnowed and all husks rejected but precautions should be taken to avoid the dust created by this operation.

It would be desirable to avoid the consumption of "exposed" crops such as cabbage and lettuce in the weeks following an attack, root crops with protection from the soil would be safer, and stored food if kept in

dust proof buildings or containers should be free from fallout and safest of all to eat. These precautions may seem relatively simple but it should be remembered that there will be no mains water, and streams and reservoirs will be contaminated, so supplies of uncontaminated water to wash these foods will be hard to obtain. (See section on *Farm Livestock*).

Internal contamination of crops: In the growing season radioactive fallout might be taken into the plant either by the roots (if there was fallout in the soil) or by absorption through the leaves, onto which the fallout had settled. Long lived radioactive elements will remain active in the soil and be available for uptake by the plant for hundreds and in some cases many thousands of years.

When these radioactive particles are taken up into the plant along with its nutrients, they will lodge in the plant, damaging nearby cells. When the plant dies and decays they return to the soil. If the plant is eaten the radioactive particles will pass into the animal or human being to continue their damage and again return to the soil either through the dung or as the body decays. *Thus each particle over its long life is available for uptake and capable for causing lethal damage time after time.* These dangerous particles will tend to accumulate in the food chains as the plants are eaten by animals and those animals in turn are eaten by insects or other animals. Hence extremely dangerous concentrations of radioactivity will be formed that will be impossible to disperse.

The plants and trees that survive the initial fallout will paradoxically be the ones that take up radioactivity from the soil and thereby become poisonous to humans and animals. No amount of washing will remove this contamination, so all food would have to be tested and unsafe food discarded.

There is tragic evidence of this in the Bikini Atoll, in the Pacific, which was used by the U.S.A. for many of the nuclear weapons tests it conducted in the late 1950's. The islanders were evacuated for the tests and were allowed back home ten years later, only to be re-evacuated after it was found that they had been subject to high doses of radiation. A U.S. Department of the Interior report said in 1983 that the islanders could return home providing that they ate no home grown food until the late 21st century. The crops grown on the island are still dangerously radioactive and coconuts, which are a staple of the Bikinian diet, are seriously contaminated with Caesium 137 and are likely to remain so for another hundred years.

This clearly illustrates the problems that will face agriculture after a nuclear war but remember that Bikini Atoll had no nuclear power stations and reprocessing plants, if these are destroyed in an attack then the radioactive contamination will be far more widespread, severe and long lived.

Grassland contaminated by fallout: As can be seen from the figures, grasses are amongst the plants most resistant to nuclear radiation exposure, however, their use as fodder for animals would be severely limited in the first few months after an attack because of contamination by fallout, which would cover the pastures in a fine dust and if eaten or inhaled by cattle, sheep or horses could prove fatal. *Home Defence and the farmer* H.M.S.O. 1958, suggests that in summer, cutting and removing the grass as hay or silage (to be tested later) and then fertilizing to encourage new grass growth, would be the most effective way of reducing this fallout risk to livestock. (Whether the farmer and his staff would wish to expose themselves still further to the radioactive fallout that would be stirred up in these operations is extremely doubtful).

Ploughing in fallout: Similarly, *Home Defence and the Farmer* H.M.S.O. 1958, suggests that, "top soil may be ploughed in so as to bury fallout as deeply as possible before planting". Again it should be remembered that ploughing and cultivating disturbs the soil and creates dust which would present a serious hazard to the tractor driver, unless he had a dust proof cab or he delayed until the fallout had lost its potency. In an emergency of this nature volunteers may well be found for these high-risk jobs. The Home Office has suggested that the most suitable volunteers would be the old or the sick, who even under normal circumstances, would not be expected to live for more than a few years, but the work could not in any way be classed as normal farm duties.

Some land, particularly that covered by fallout from devastated nuclear power stations, will be unfit for cultivation for a very long time because of the long lived radioactive contamination. This will create a serious ecological problem but strangely in the short term, this may not create an agricultural problem. Because of the expected small number of survivors and the small acreage of land that each could work by hand it is estimated that there would be a 73% decrease in the land used for crops. Most of the farmers on the badly contaminated land would be dead and surviving farmers in other areas would be hard put to it coping with their own land, without looking for expansion, so large acreages of farm land would probably remain desolate.

Exposure of trees to nuclear radiation: Conifers, surprisingly, are very susceptible to nuclear radiation and their L.D. 50 is only 450 rads. As much of the conifer forests would be destroyed after a full scale nuclear attack, by huge forest fires, this vulnerability may not be important.

Deciduous trees have an L.D. 50 of 1,800–3,800 rads, low enough to suffer serious damage in many areas after a full scale attack.

If there is a recovery then trees, of all kinds, will play a vital role in the post attack economy. The fact that they have died from radiation exposure will not reduce their value as timber, for rebuilding houses and farm buildings, or as stakes for fencing, or simply as firewood for much needed warmth. But they should not be used until the radioactive fallout on them has been washed or blown off, or it has lost its potency.

FARM WARDENS

As mentioned in the last section at the onset of hostilities the Area Agricultural Officer and his Farm Wardens will take control of all farming production[6] and if they survive, they, together with Civil Defence personnel, will try to assess the number of people and the amount of food that has survived the attack and estimate when the next crops will be fit for harvest. They will then commandeer, ration and distribute the food as best they can. Seed corn would be held back but farmers will need secure stores to stop it being eaten by the starving population.

Farm Wardens will also advise on the levels of radioactivity in local areas and decide if and when it will be safe to resume farming duties. They will liaise with Civil Defence personnel to direct workers to farms that will be without machinery, and in much need of extra labour to sow, cultivate and harvest all crops. With the monetary system in a state of collapse it is thought that this type of work will be rewarded with basic meals, and for a population desperately short of food, these meals will act as an incentive to persuade the large numbers of people who will be needed, to labour long hours in the fields.

SUMMARY

Farm crops will sustain heavy losses in a nuclear war, just how seriously yields will be reduced will depend upon the time of year the attack takes place. If a complete harvest is lost then it would be unlikely that there would be sufficient food to provide an adequate calorie intake for the workers who would have to cultivate, plant and harvest the next crop by hand before it could be eaten. In fact it would not be until the second or third harvest after the attack that a population (much reduced by starvation) would be in balance with food supplies, especially as the primitive farming techniques that would have to be learnt, would not be very productive. The diet, in the main, would be grains and potatoes, with a little milk for children, some eggs and some meat (mainly mutton) from rough grazing.

CONCLUSION

Having read this guide you will be left in no doubt about the appalling consequences that a nuclear war would have on agriculture and, therefore, on the fate of the human race. It will destroy our environment and with it the very basis of our survival, the ability to grow food.

There is a view that these findings can only confirm the value of the world's present nuclear policies by making a nuclear war that much more unthinkable. This view is based on the premise that at all times Man has complete control over these weapons and it allows for no possibility of mistakes, no human or computer errors and no accidents. Nothing Man has ever devised has been completely foolproof and as long as we have nuclear arsenals the almost unbelievable circumstances described in this guide could become reality.

It is for this reason that it is so necessary for all of us to be aware of the facts and the issues involved so that we can use this knowledge to convince all Governments that they must adopt policies that will guide mankind away from its present perilous path and into a NUCLEAR FREE FUTURE.

REMEMBER WE DO NOT HAVE TWO EARTHS, ONE TO EXPERIMENT WITH THE OTHER TO LIVE ON.

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