

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 deciduous 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.

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.*, "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 1/4 million years.

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 estimated¹ 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 neutralised, 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 1/4 million years. Protection from beta and alpha radioactive particles is only achieved if all fallout is 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 radioactive fallout that has lodged on or in the soil.

The following table gives an indication of the relative susceptibility of farm livestock in buildings⁴ :—

<i>Animal</i>	<i>L.D. 50 Exposure dose. (Rads)</i>
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 tins way may not be thought of as worth while, since the farmer and the stockman may not wish to jeopardise 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 officer⁵ 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.

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' 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* 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.

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 fertilisers 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 calculated³ 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 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 Rads
Barley	300 to	1,250 Rads
Wheat	500 to	1,750 Rads
Lettuce	2,000 to	2, 500 Rads
Sugar Beet	1,250 to	4,000 Rads
Potatoes	1,000 to	4,500 Rads
Tomato	2,500 to	5,000 Rads
Rice	5,000 to	12,500 Rads
Grasses	1,000 to	12,500 Rads