New Zealand After Nuclear War

THE BACKGROUND PAPERS

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CONTENTS

BACKGROUND PAPER 3

IMPACTS ON NEW ZEALAND'S NATURAL ENVIRONMENT

by

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This is one of a set of background papers prepared, in consultation with the Nuclear Impacts Study Team, from material provided by a wide range of contributors for a study of the impacts on New Zealand of a major nuclear war. Along with other sources the papers comprised the basis of the book ***New Zealand After Nuclear War****, by Wren Green, Tony Cairns and Judith Wright, published by the New Zealand Planning Council, 1987. The assumptions that the study was based on are explained in Background Paper 1, note particularly the assumption that New Zealand is not a target, and the variable assumption involving an electromagnetic pulse (EMP - for an explanation, see Background Paper 5).*

SUMMARY

A nuclear war in the Northern Hemisphere is unlikely to have direct catastrophic effects on New Zealand's natural environment and most of the changes would be reversible. A 3°C drop in spring temperature, a summer drop of 2°C and a 1°C drop over the following 18 months, a 20% reduction in light levels and a 50% increase in ultra-violet radiation would probably have wide-ranging temporary effects on the natural environment. A 3° drop in spring temperatures would stunt the growth of forests and possibly kill radiata pine plantations over large areas of the inland North Island and upland South Island. The indirect or imported consequences of a nuclear war would probably be more profound. Disruptions to fuel supplies, transport and farming would probably mean very large areas of marginal farmland would revert to scrub and bush. Rabbits, deer, goats and pigs would probably return as major pests on farmland and upland New Zealand; and insects return as serious damaging pests of crops and stored foods. Coastal fish stocks would probably be heavily depleted especially near larger areas of population. Flood control, sewage disposal, river and estuarine pollution would probably be major problems.

CLIMATIC CONSIDERATIONS

The effects of lowered temperature and reduced light on the natural environment can be simulated by considering:

- the present latitudinal and altitudinal differences in temperature and light within New Zealand;
- temperature variations over 120 years of records;
- experimental conditions of temperature and light under which plants will grow;
- phenological observations on wild plants and animals in New Zealand over

the last century;

- evidence for climatic change in New Zealand over the last thousand years based on variations in glacial termini and snow lines; cave palaeo temperatures; distribution of icebergs; pollen analysis; tree ring analysis; erosion and aggradation regimes of rivers catchments; closed-basin lake variations; decline in altitudinal limits of trees; migration pattern of trees; invasion of bog areas by forest and scrub; the instability of tree population structure; recent effects of drought on forests (Burrows & Greenland, 1979; Wardle, 1963; Wilson, Hendy & Reynolds, 1973).

It has been shown that New Zealand underwent a "little ice age" between 1550 and 1700 AD when the mean temperature of New Zealand dropped from 12.3°C to 11.4°C (Wilson et al., 1971). A prolonged cold spell overtook New Zealand between 1900 and 1910. During this period the mean temperature from Auckland to Dunedin fell by about 1°C (Coulter, 1973). The New Zealand natural environment survived and recuperated from these prolonged cold episodes although a more gradual period of onset may have provided more time to adjust.

The average July temperature in Auckland is 10.9°C. If the temperature were to drop by 3°C, Auckland's July temperature would resemble Wellington's. A fall of 3°C in the mean July temperature of Christchurch would produce winter temperatures resembling those presently experienced by, for example, Alexandra. Auckland enjoys an average 2100 hours of sunshine annually. A 20% reduction in Auckland's sunshine would bring it on par with, for example, Dunedin which has about 1680 hours of sunshine annually. In keeping a perspective on reduced light levels it is useful to consider that Rotorua, for example, enjoys 33% more solar radiation (GJ/m2/year) than northern Europe. Darwin enjoys 34% more solar radiation than Rotorua. A 20% reduction in Rotorua's light would produce a regime perhaps resembling that of present-day central Europe.

As a rule of thumb, the mean air temperature falls by 6°C with each 1000 m rise in altitude. In the event of a 3°C fall in mean temperature the climate of coastal and lowland areas would come to resemble the temperatures experienced presently at 500 m above sea level.

Many of the predicted temperature and light changes therefore, fall within the range already experienced naturally in New Zealand. These geographic and historical climatic patterns enable us to predict the effects of prolonged cold episodes on the natural environment within fairly broad limits.

In continental North America and Europe, a sustained drop of 3-5°C will probably produce continuous cold weather (Pittock et al., 1986). At our latitude, and because we are an island country, the New Zealand climate will remain oceanic in character, despite a 3-5°C fall in temperature. The winters will lengthen but warm and cold sequences of weather will still occur even in winter. Ice age studies show that regional westerly winds are stronger during periods of colder climate as strengthened mid-latitude westerly circulation prevails (Salinger, 1983).

ULTRA-VIOLET (UV) LIGHT

Many studies have demonstrated that photosynthesis is inhibited by UV-B radiation. In addition, it has been shown that UV-B radiation can affect leaf expansion, abscisic acid content, pigment concentrations, plant growth, carbohydrate metabolism, fruit growth and yield, pollen germination, and pollen tube growth (Harwell, 1985).

High-level ultra-violet light can kill small plants and can genetically damage them (Caldwell, 1980; Levitt, 1983). Part of the ultra-violet B radiation damages DNA. This portion of the ultra-violet increases 42% between 1500 and 3300 m a.s.l. (Caldwell, 1980). The effect of a 50% rise in ultra-violet radiation, therefore, can be measured under present-day circumstances in New Zealand. While native alpine and high-altitude plants and animals are already adapted to living at these ultra-violet intensities the impacts on lower altitude plants adapted to much reduced levels could be an issue. Further research is needed to determine such impacts on important crop species.

ALPINE AND UPLAND REGIONS

Burrows and Greenland (1979) have shown that areas of permanent snow expand and contract the snow line, and that the termini of New Zealand glaciers have moved in response to prolonged warming and cooling episodes over the last 1000 years. It is expected that if cooler conditions return there will be an increase in permanent snow cover, a lowering of the snow level and an increase in the glaciers. If temperatures return to normal after 24 months, as is proposed in the scenario, snow, ice and glacier levels will probably return to their previous condition. The spring thaw is likely to be delayed. Alpine lakes already freeze in winter. Lower temperatures will freeze the lakes earlier in the season and the ice will be thicker. Some shallow lakes will freeze to the bottom, killing all aquatic life. Sustained low temperatures will delay the thaw and may create a shortage of water for downstream rivers and lakes.

Alpine plants and animals

Many alpine plants and shrubs depend on high summer temperatures to promote flowering (Mark, 1970). Snow tussock and speargrass for example, only flower after high summer temperatures. Many subalpine shrubs require several years to accumulate enough nutrients to allow them to flower and fruit. Reduced summer temperatures will halt the flowering of alpine tussock and increase the number of the years between flowering of the shrubs.

These are all perennial plants which will probably survive several years of poor flowering or no flowering and eventually resume their normal pattern. Several animals live and breed above the timber line - keas, rock wrens, blue duck, crested grebes and alpine moths and butterflies. These are cold-adapted species and adaptable enough to move to lower altitudes if their usual habitat becomes exceptionally cold.

NATIVE FOREST

All plants have a range of temperature tolerance within which they can live. The alpine timber line is the highest elevation at which shoots of woody plants can grow and ripen and is set by the prevailing minimum temperatures. Black beech, for example, grows to an elevation of 1440 m near the East Cape of the North Island and to 944 m in Central Fiordland. Silver beech grows to 1280 m in the Tararuas and 980 m in Fiordland. Kamahi grows at 1097 m on Mt Tarawera and 700 m in Fiordland. During the intense cold of the Pleistocene Ice Age this timber line was driven down below the present day sea-level so that New Zealand was almost without forests. A smaller drop in timber line was probably also experienced during the little ice age of the 17th century. Many New Zealand plants have southern geographic limits which are set by the temperature. For example, the southern limit of the tree tawhero lies at 39°, of rewarewa at 47°, and of nikau at 44°S. By analogy with conditions during the recent ice ages a return to colder conditions would presumably drive these southern limits further and further north. The conditions envisaged in this nuclear scenario do not approach those of the Pleistocene ice age when mean temperatures dropped 5 or 6° for thousands of years. Drastic changes in timber line or southern geographic limits can not therefore be expected. Conditions approaching those of the little ice age of the 17th century are, however, likely to prevail though only for a period of 18 months. Many of New Zealand's largest and oldest trees which include 600 year old kauri, matai and totara, for example, have already demonstrated their ability to withstand prolonged periods of cold weather as these have survived the 17th century ice age.

Compared with plants from continental areas of the northern hemisphere, New Zealand plants have comparatively low resistance to freezing temperatures. Most trees and shrubs growing naturally in New Zealand show well-defined geographic limits along various temperature-related gradients, and freezing resistance of the plants correlates well with their natural distribution. A temperature of -4°C will kill many broadleaved plant species which presently grow above 39°S. The hardiest native, high-altitude conifers, however, require temperatures of -18°C to -25°C to kill them (Sakai & Wardle, 1978). A temperature drop of 3° in spring followed by 19 months at 1° will increase the severity of frosts and probably stunt and kill a few native species at the altitudinal or geographical limits of their range.

Prolonged sunshine is needed to ripen many fruit crops. Although little evidence is available to prove the point, the fruit of many New Zealand native forest trees probably also require prolonged sunshine or heat to mature and ripen. A temperature drop of 2° throughout the summer accompanied by lower light levels, may prevent the development and ripening of many native fruits and berries. This crop failure may be of little consequence to the trees which may resume the production of fruit when the cold episode has passed. However, the absence of ripe fruit, berries and seeds could profoundly affect many nectar, fruit and berry-eating native birds, insects and bats.

RADIATA PINE PLANTATIONS

Radiata pine is not grown commercially in New Zealand on sites with average annual temperatures below 7°C. As an example, the mean annual temperature at the Chateau, Mt Ruapehu, is 7.2°C and at Naseby is 8°C. Ten days with a mean daily minimum temperature of -8°C will kill all radiata pines. Experiments with trees grown outside show that mid-winter frosts of -12°C are needed to kill radiata pine seedlings which have been grown in a cold environment (Menzies et al., 1981).

A 3°C drop in summer temperature would have little effect on radiata pine. A 3°C drop in spring temperature would coincide with the spring flush of growth and in many upland and inland areas this would have a lethal effect on radiata pines. Frosts would kill most radiata pine in the main central North Island forestry region, including the Bay of Plenty and the Taupo basin and most of the South

Island pine forests especially in Canterbury and Southland. Nelson and Westland forests should escape these effects (Menzies in litt., 1986).

REDUCED LIGHT LEVELS

The amount of growth put on by plants is directly related to the amount of sunlight their leaves intercept. It has been well established that the less light intercepted by crops in Britain (Monteith, 1977) and pine and gum forests in Australia and New Zealand (Linder, 1985) the less growth will follow. It has been calculated that a 20% drop in light reduces tree growth by 25%. Any reduction in light levels will slow the growth of plants in New Zealand including native forests and pine plantations.

WEED AND PESTS

A nuclear war in the Northern Hemisphere would severely disrupt New Zealand farming practices. Chemical fertilisers, herbicides, insecticides, wire, agricultural machinery and equipment, fuel and spare parts will be in very short supply (Royal Society of New Zealand, 1985). The difficulties, if not the impossibility, of topdressing, fencing, controlling weeds and pests would very soon become apparent and large areas of marginal and upland country would be abandoned. This abandoned farmland would soon revert to scrub and become the home for increased populations of possums, pigs and goats. At high altitudes, goats and deer are today controlled by helicopter operations. Labour, imported poisons and ammunition also contribute to these operations which would certainly stop in the event of a nuclear war. Within 3 or 4 years, deer and goat numbers would rise to pre-1960 levels. It is probable that animal control issues could receive very low priority in the New Zealand after a nuclear war. Without trade there would be no commercial export of wild animal products and without trade we would be unlikely to have the domestic resources to do anything about them. In the absence of high-tech insecticides, insect pests would certainly make severe inroads into products on the farm or in storage.

LAND ANIMALS

The environmental temperature plays a major role in setting the geographic distribution, abundance and breeding patterns of many New Zealand native animals. For example, kauri snails are found only as far south as 35°, Suter's skink as far south as 37°, the Moko skink and the Shore skink as far south as 38°, marsh crakes to 39°, Pacific geckos to 40° south. All these creatures survived the little ice age of the 17th century, but with extensive settlement the face of the New Zealand countryside has changed and many of these animals now survive only in small sub-optimal patches of habitat. Prolonged cooling, even of a degree or two, could possibly see the extinction of the northermost kauri snails and lizards.

Temperature profoundly affects the abundance of many animals, especially cold-blooded creatures. Moeed and Meads (1984, 1985, 1986) clearly showed that the numbers of most native forest invertebrates (insects, spiders, woodlice, etc.) rise and fall with the temperature. Invertebrates are also less abundant at higher, cooler elevations (McColl, 1974). Any depression in air or soil temperature will almost certainly reduce the abundance of most invertebrates and slow, if not prevent their breeding.

A drop in temperature would affect birds and mammals by:

- Direct exposure to cold. Death from exposure is a very powerful factor in controlling the abundance of wild animals. Most animal species are very sensitive to minimal temperatures and a drop of even one or two degrees can have a devastating effect on their numbers.

- Reduced food supply. Lowered temperature and light levels are likely to produce poor crops of flowers, nectar, berries, fruit and insects. Wild animals which feed on nectar, fruit, berries, seeds or on insects will be in very poor condition following years of poor flowering and fruiting. These animals may never survive the winter cold or if they do may never reach breeding condition the following season.

- A drop in light levels. Many mammal and bird species are brought into breeding condition by changing day/night ratios and by changing intensities of light. A 20% drop in light levels is not likely to have a profound effect on animal breeding though some species, e.g. sheep (Averill, 1964) may delay their onset of breeding by a short period.

RIVER AND LAKES

While the daily fluctuations in the temperature of freshwater systems is moderated by the high specific heat of water, this moderation is reduced in the longer term. (The daily variation in the temperature of the Waikato River at Hamilton in summer is 1.7^{O}C compared with variations in air temperature of 6.5^{O}C.) The temperature of large lakes, such as Lake Taupo, is only slightly moderated compared to air temperatures. Smaller lakes will follow air temperatures more closely. A temperature drop of 2^{O}C for more than a year will be reflected in a similar drop in the temperature of even our largest lakes.

All plants and animals have upper and lower lethal temperatures but temperature can act on any stage of the life cycle to limit survival, reproduction, or the development of the young. Competition between organisms, predation and parasitism can be much more intense at the lower limits of temperature tolerance.

Our native freshwater plants and animals are generally cold-water tolerant. Introduced fish, such as catfish and guppies, are warmer-water fish and may respond to lowered temperatures with reduced productivity. Trout and salmon may spread and increase as their distribution in the North Island is limited in part by warm water.

Reduction of light intensity

Light penetration controls biological productivity in most shallow turbid lakes, and can be critical in the survival of waterweeds. The recent disappearance of waterweeds from several shallow New Zealand lakes highlights their importance and the fragility of these systems.

However, the degree and duration of light attenuation proposed are probably within the normal variations in light intensity experienced by these plants and is unlikely to create serious problems. The behaviour of lake and river animals is unlikely to be adversely affected.

Ultra-violet light

Ultra-violet light can reduce the growth of waterweeds and plant plankton in freshwater. While excessive weed growth is a problem in many New Zealand lakes, the ecology of these lakes may be finely balanced so an increase in UV light may shift the dominance to other even less desirable plant species. This may also happen in rivers and reservoirs and limit the potability of these waters.

Airborne pollutants

It is predicted that latitudes 20°S to 40°S would receive rain at pH 4.3 for the first two weeks and 4.9 for the following six months (Galbally et al., 1983, cited in Green, 1984). The effect on the pH of the receiving water depends on the buffering capacity of those waters and on the pH of runoff entering the water body as some neutralisation may occur. As alkalinities in New Zealand freshwateres are generally less than the world average, our lakes are more sensitive to a given input of acidic rainfall.

When pH drops below 5.0 fish begin to die and the productivity of aquatic ecosystems is considerably reduced. Low pH can affect the hardness of water and affect animals such as mussels and freshwater sponges. Some metals are more toxic in water of reduced hardness. Increasing acidity can increase the mobility of toxic metals and other radionuclides. Because we have so little information on the type and quantity of airborne pollutants that could be expected after a nuclear war, we cannot predict the size of these impacts but they are likely to be minor compared with others.

Effect of reduced light intensity on freshwater systems

The degree and duration of light attenuation proposed are probably within the normal variations experienced by waterweeds and plankton in New Zealand today and would probably not create serious problems. The behaviour of aquatic animals is also unlikely to be affected adversely.

EFFECTS ON MARINE ECOLOGY

A temperature of 2°C for at least 2 years would be unlikely to eliminate many marine species, nor would it be likely to affect the distribution of many species in the longer term. However, New Zealand is spread over a long latitudinal range and some species are living close to their temperature limits either upper or lower. These species would be likely to have their populations affected more drastically than the widespread species that live along the whole coast. Species could be affected in both summer and winter.

Many species might not breed during the cooler temperature or if they did, their larvae might not find enough planktonic food. This could remove whole year-classes from the populations which would be reflected in reduced reproductive success in future years. Short-lived species would be likely to be affected much more than those which normally live for several years. Important short-lived species include those at the base of the food chain such as plant and animal plankton as well as some commercial species such as squid.

COLLAPSE OF WASTE TREATMENT SYSTEMS

Many major industries in cities in New Zealand discharge treated wastes into our major rivers or lakes. There are a number of mechanisms by which the functioning of these systems may be disrupted:

- Electromagnetic pulse (EMP). The most critical aspects would be the plant's chlorination system which depends on micro-processor control and relatively large quantities of electricity for the production of hypochlorite from brine.
- Lack of spare parts for maintaining equipment. Pumps and valves would be difficult to replace.
- If waste-treatment workers and technicians failed to report for work.
- Power failures.

If water supply systems failed for any reason and if a reduction in rainfall reduced the flow of smaller streams, the public might be forced to take water from the larger rivers. The Waikato River, for example, would become seriously polluted downstream of Hamilton if that city's water pollution control plant failed. There are a number of other major discharges to the river such as the NZ Electricity Wairakei Power Station, NZ Forest Products at Kinleith, AFFCO Horotiu Abattoir, and NZ CDC Te Rapa Dairy Factory whose waste-treatment systems may also be affected.

The problems would not necessarily be restricted to the large rivers as many provincial centres discharge industrial and domestic effluent into small water courses.

LOSS OF FLOOD CONTROL

Many waterways in New Zealand incorporate major flood control works and this has allowed the development of previously flood-prone areas. The operation of some of these systems relies on computer control while all have electric motors to operate floodgates. Although many of these gates can be operated manually, this is innacurate and tedious and gates may have to be set at compromise levels (Zuur in litt., December 1986).

FISHING

The New Zealand fishing industry depends upon overseas supplies of engines, compressors, freezing equipment, valves, tubing, electric motors, alternators, generators, radar, sonar, depth sounders, marine radios, prop shafts, fish netting, fuel and lubricating oils. Without these supplies New Zealand's fishing industry would be completely disrupted. Open-sea fishing would be almost an impossibility. Refrigeration of fish may be too energy-consuming to contemplate and old methods of salting and drying may have to be used.

People may move to coast and estuaries in order to exploit the crustaceans, shellfish and fin fish. If waste-water treatment systems have failed on a large scale, harbours, estuaries and their marine life will probably become contaminated. Radioactivity levels may also be high among estuarine fish. It is possible that individuals and groups may harvest the available resources of the littoral seas to extinction.

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