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THE ENVIRONMENTAL CONSEQUENCES TO NEW ZEALAND OF NUCLEAR WARFARE IN THE NORTHERN HEMISPHERE

Council of the

New Zealand Ecological Society (Inc.)

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A Statement of Concern by the Council of the New Zealand Ecological Society (Inc.)

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The New Zealand Ecological Society is a scientific society formed in 1951 "to promote the study of ecology and the application of ecological knowledge in all its aspects". It draws its membership primarily from research and teaching institutions. On three occasions in its history the Society has prepared substantive statements on ecological issues it regarded as of national importance: the utilisation of South Island beech forests (1973)[1]; a population policy for New Zealand (1974)[2]; and the generation of nuclear power in New Zealand (1977)[3].

The Council of the New Zealand Ecological Society has undertaken an assessment of the scientific evidence on the environmental consequences to New Zealand, of nuclear warfare in the Northern Hemisphere. Its conclusion is that even a small-scale nuclear war confined to the Northern Hemisphere will have far-reaching and, in some cases, unpredictable consequences for the New Zealand environment. The Council now believes it cannot continue to promote concern for the New Zealand environment and yet remain silent over the threat to world ecosystems posed by nuclear armaments.

This statement, which summarises published information available to the Council up to July 1984, is an apolitical expression of concern. It seeks to convey to a wider audience the likely effects of a Northern Hemisphere nuclear war on the New Zealand environment, and to identify issues requiring action within New Zealand.

INTRODUCTION

Many people derive their understanding of the consequences of nuclear war from the bombing of two Japanese cities, Hiroshima and Nagasaki, at the close of World War 2. The scale of the immediate death and destruction was appalling, and so too has been the suffering and death of people with radiation sickness over the succeeding 40 years. On that evidence alone, there are unpleasant long-term consequences for humanity from a nuclear exchange. Today, there are so many nuclear warheads spread around the world[4] that their effects following deliberate or accidental use will, in all probability, be neither so localised nor so brief.

Attention has naturally centred on the immediate human plight[11], rather than the consequences for global ecosystems upon which humans depend for their survival. Attention has also tended to focus on effects within the Northern Hemisphere where most nuclear weapons are presently deployed and where, it is believed, nuclear war is likely to be confined.

> *Before 1982 it was thought that the effects of any nuclear exchange between Northern Hemisphere combatants would be confined to the Northern Hemisphere. There is an increasing body of evidence to suggest that this view is no longer tenable. It is this evidence that prompts the Council's concern and which forms the basis of this statement.*

PREDICTING THE ENVIRONMENTAL CONSEQUENCES OF NUCLEAR WAR

Initial scientific efforts at estimating the global effects of nuclear weapons concentrated on radioactive fallout. This research by scientists from both East and West contributed to the 1963 ban on atmospheric nuclear tests[20]. In 1975 a United States National Academy of Sciences study[21] highlighted the likely long-term effects of increased levels of ultra-violet radiation that would result from the depletion of the ozone layer in the upper atmosphere.

The next international attempt to assess the human and environmental consequences of nuclear war was begun in 1980 by the editors of Ambio, the International Journal of the Human Environment published by the Royal Swedish Academy of Sciences. Their study assumed the explosion of 5742 megatons, or less than half existing stockpiles. Only 173 megatons was assumed to be exploded in the Southern Hemisphere. Further assumptions were made about the location, timing and size of all nuclear explosions. The results were published in 1982[12]. Since then another large collaborative effort has tested and extended those results[22,23]. These studies have been based largely on computer predictions of how the atmosphere would respond to massive disturbances. Mathematical equations which describe the workings of the atmosphere and climate patterns are placed within a computer and linked to form a 'model'. Terms in these equations are given a range of values within the computer and so the response of the atmosphere under these differing circumstances can be determined. Work on further refinements and evaluation of various climate models is underway in several institutions[24], and results are now reaching the scientific literature[25]. A major international project has begun to examine the environmental consequences of nuclear war[26], and its findings are due to be reported in September 1985.

These studies all stress the difficulties of predicting the environmental consequences of nuclear war. These arise for three reasons:

(i) Scientists normally require experiments to test ideas about how systems function naturally and when disturbed. This is impossible in the case of nuclear war and its environmental consequences.

(ii) There is uncertainty from not knowing how, and when, nuclear war might be fought, and how many nuclear warheads might be exploded. It is, therefore, difficult to estimate the quantities of dust, smoke toxic vapours and radioactivity that would be generated and their subsequent impact on global climate, plants and animals. In some important aspects of the inquiry (e.g. the microphysics of clouds, coagulation processes in smoke clouds, and the interdependence of some climatic processes[32]) present research will help reduce the level of uncertainty.

(iii) Both climatic and ecological responses to major stresses are likely to be complex and hard to anticipate. Ecologists can only guess at the possible consequences when the effects of all responses are combined[27]. Nonetheless, such guesses are useful insofar as they indicate what <u>might</u> happen and what further information should be gathered and examined.

Scientists have attempted to cope with these uncertainties by using computer models referred to above[21-25,29]. One study[22] modelled the effects of 18 different nuclear war possibilities, ranging from a 100 megaton attack exclusively on cities, to a "baseline exchange" of 5000 megatons (cf. the <u>Ambio</u> study which assumed 5742 megatons[12]), and a "future war" of up to 25 000 megatons.

From these studies a general trend is emerging. It is that the environmental consequences of any nuclear war may be more complex, more widespread and more devastating than were first thought. Radioactive fallout, the topic of early investigations, may not be the major consequence to consider. Much more serious effects might arise from the generation of dust and smoke, lowered temperatures, depletion of the ozone layer, increased ultra-violet radiation, and severe climate changes. Furthermore, these consequences may spread through the disrupted atmosphere well beyond the area of conflict to have a truly global effect.

The principal physical effects resulting from a nuclear war in the Northern Hemisphere and their likely environmental consequences in the Southern Hemisphere are briefly summarised here from the listed references.

THE PHYSICAL EFFECTS

1. <u>Climate changes</u>

Changes in southern climates will largely depend on what happens in the Northern Hemisphere. Before 1982 such changes were predicted to be minor. A major nuclear war was not expected to disrupt the relatively weak interchanges across the climatic equator (Figure 1) in the lower atmosphere (troposphere) thus ensuring that most of the radioactive fallout and other nuclear pollutants would be confined to northern latitudes.

In 1982, it was suggested[28] that multiple nuclear explosions would initiate huge fires in urban and industrial areas of stored fuels, oil and gas fields, and forests. These "nuclear fires" were predicted to produce 200 to 300 million tonnes of smoke after a 5700 megaton war and, unlike normal dust or volcanic ash, the smoke would strongly absorb sunlight. This material would be injected into the lower atmosphere and would spread over the Northern Hemisphere within two weeks.

This phenomenon of massive smoke clouds would have three major effects. The first would be to reduce the amount of sunlight reaching the earth's surface in parts of the Northern Hemisphere to as little as 1% of normal levels[22,29]. Following a severe (10 000 megaton) nuclear war, sunlight would be reduced to 1-5% of normal for up to three months. Even relatively small nuclear wars could precipitate a long period of twilight[22].

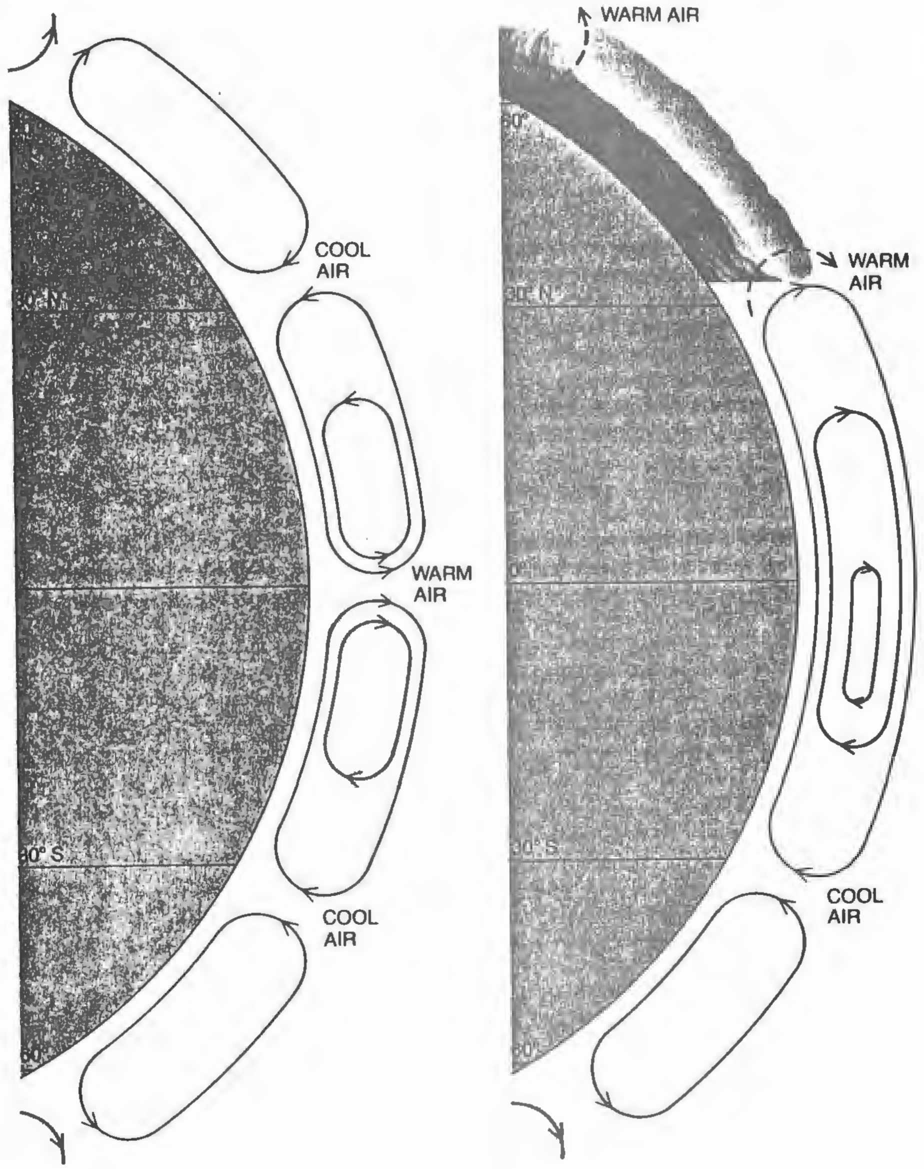

FIGURE 1 : The pattern of air circulation in the atmosphere could be disrupted by a major nuclear war in the Northern Hemisphere. During the northern spring and summer, air rises over the hot humid Tropics, splits into two streams and descends over the subtropical and middle latitudes of both hemispheres to create secondary areas of air circulation at higher latitudes (diagram at left). If a large, dense cloud of smoke and dust were to be introduced into the lower atmosphere in the northern temperate latitudes during these seasons, the heating at the southern edge of the cloud might be intense enough to reverse the normal mid-latitude descent of air and create an unusual air flow pattern in which upper-level winds blow briskly across the equator from north to south (diagram at right). Adapted from Scientific American, Vol.251 (August 1984).

The second major effect would be to lower temperatures over northern continents. The black clouds would absorb incoming solar radiation and prevent warming of the earth's surface. However, surface heat would radiate through the clouds back into space as longer wavelength (infrared) radiation. Thus the northern continents would rapidly cool and sub-freezing conditions could be widespread within 10 days[25,29]. The temperature drop would be less near the coasts because of the large amount of heat stored in the oceans. However, the large temperature differences between the oceans and the continental interiors could lead to rapid air flows, violent coastal storms and flooding.

Present results from climate models do not predict such extended periods of freezing for the Southern Hemisphere[22,25] but significantly lower temperatures may occur in southern mid-latitudes over large land surfaces, especially Africa[29]. Around New Zealand, the ocean would moderate any temperature reduction, perhaps making sub-freezing conditions unlikely, but unseasonably cool temperatures could occur[29]. Further modelling of Southern Hemisphere climates will be required to establish the likely extent of temperature drops in New Zealand.

While temperatures at ground level over northern continents decline, solar radiation may heat the top 1 km layer of the black cloud mass sufficiently to lift it from the lower atmosphère into the upper atmosphere (stratosphere)[30]. If that happened, the smoke could cover the whole earth and persist for months, maybe years. Calculations using the Ambio assumptions[12] showed that if 50% of the nuclear debris was dispersed over the globe as an aerosol layer, it would "absorb or reflect approximately 80% of the incoming solar radiation"[30]. New Zealand and the entire Southern Hemisphere would be affected by this global darkening.

The third effect of the smoke would be to actively transfer nuclear pollutants, soot and dust into the Southern Hemisphere via the upper atmosphere (Figure 1). The temperature inversion resulting from a cold earth surface and warm lower atmosphere could establish differences in surface temperatures between the Northern and Southern Hemispheres sufficient to cause a movement of air into the Southern Hemisphere[32]. Hence pollutants could be carried rapidly southwards in both the lower and upper atmospheres.

Tentative conclusions from the simulation models[22] are that:

> "Relatively large climatic effects could result even from relatively small nuclear exchanges (100-1000 megatons) if urban areas were heavily targeted, because as little as 100 megatons is sufficient to devastate and burn several hundred of the world's major urban centres. Such a low threshold yield for massive smoke emissions ... implies that even limited nuclear exchanges could trigger severe after-effects."

2. Nuclear-generated pollutants

The term nuclear-generated pollutant describes all material deposited on the earth's surface as a consequence of nuclear explosions and subsequent fires. Such pollutants include radioactive substances, toxic gases, oxides of sulphur and nitrogen, and acid rain.

The radioactive fallout most likely to affect New Zealand and Southern Hemisphere environments and human health would be strontium-90 (^{90}Sr) and caesium-137 (^{137}Cs). Since their half-lives[33] are 28.5 years and 30 years respectively, their presence would be apparent for many years after a nuclear war. Strontium-90 is chemically similar to calcium and accumulates in bone, marrow, shell and fish scales[34]. It irradiates the white-cell-producing bone marrow with beta radiation and increases the incidence of leukemia and bone cancer[5].

Because of the chemical similarity of caesium and potassium, caesium-137 is concentrated in soft tissues, including muscle. It emits beta and gamma radiation thus posing a particular hazard to reproductive organs. Uptake of caesium-137 would be greatest in humans and animals that ate a lot of meat[5]. Local factors would also have an effect; for example, increased accumulation of caesium-137 in milk and meat occurs where soils are acidic[5].

Using the Ambio study as its basis and applying conservative assumptions about the quantity of radioactive material that would be transported into the Southern Hemisphere, one study team[30] estimated that levels of strontium-90 would rise five-fold over that recorded during atmospheric tests of nuclear weapons in 1967. If all nuclear reactors were hit, each by a one megaton bomb, average levels may rise to 30 times, and in regions of high rainfall up to 100 times that recorded in 1967. Caesium-137 would be similarly distributed but levels may be greater.

If, during a major nuclear war, some nuclear weapons were exploded in the Southern Hemisphere (the Ambio study assumed 5569 megatons would be exploded in the Northern Hemisphere and 173 megatons in the Southern Hemisphere[12]), southern regions affected by local fallout would be contaminated by radioactive iodine-131. This pollutant is very common in nuclear fallout but because it has a half-life of only eight days, it is not dispersed far beyond the immediate area of the explosion. Iodine-131, which readily contaminates freshwater environments[35], emits beta and gamma radiation, and is concentrated in the thyroid gland where it causes cancer[5].

While radioactive materials are probably the best-known fallout product, they are not the only pollutants that would have long-term effects on the Southern Hemisphere. Fires consuming the major Northern Hemisphere cities could produce hundreds of tonnes of toxic

gases (pyrotoxins), including dioxins and carbon monoxide[36]. These could blanket the Northern Hemisphere and a proportion would be carried southwards as a consequence of atmospheric disturbances.

The fires would also add large quantities of oxides of sulphur and nitrogen to the northern atmosphere. The quantities likely to be released under the assumptions of the Ambio study would cause rainfall in the Southern Hemisphere to be strongly acidic[31]. For latitudes 20°S-40°S (New Zealand is 34°S-47°S) rainfall with a pH of 4.3 for the first two weeks and pH 4.9 for the next six months is predicted[30] compared with New Zealand's present rainfall of about pH 5.6. As the oxides of sulphur and nitrogen are washed from the atmosphere, the acidity of the rainfall will decline and return to normal levels. However, the acid rainfall predicted will affect fish, other aquatic life and some terrestrial plants and animals[37].

3. Ultra-violet radiation

Within the upper atmosphere, oxygen is transformed into ozone which is then dispersed as an atmospheric layer enveloping the earth. This ozone layer has the ability to absorb incoming ultra-violet radiation and thus protects the earth's surface from the effects of this biologically-damaging radiation.

When the quantity of ozone in the upper atmosphere is reduced, there is a corresponding increase in the amount of ultra-violet radiation reaching the earth's surface. However, that increase is disproportionate; a 10% decrease in ozone above the Southern Hemisphere would increase ultra-violet radiation levels by 20-30%[30].

Oxides of nitrogen in the upper atmosphere reconvert ozone to oxygen, thus depleting the ozone layer. Enormous quantities of these oxides are produced by nuclear explosions[28,38]. A major nuclear war which exploded 10 000 megatons and caused massive fires may deplete the ozone layer over the Northern Hemisphere by 30-70% and over the Southern Hemisphere by 20-40%[21,23]. It would be three years before the ozone layer was restored[21].

The magnitude of the effect in the Southern Hemisphere remains uncertain, but the dispersal of the oxides of nitrogen southwards as a result of atmospheric disturbances would ensure an effect over the entire hemisphere, including the Antarctic, two years after a major war[28]. Dense smoke clouds may partly compensate for the ozone depletion by absorbing some of the radiation[30] so that a doubling of ultra-violet radiation levels in the Southern Hemisphere is possibly a 'worst case situation'.

THE ENVIRONMENTAL CONSEQUENCES

The physical effects reviewed above - reduced sunlight, lowered temperatures, disrupted climate patterns, radioactive fallout, acid rain and increased levels of ultra-violet radiation - will generate far-reaching ecological effects. Since most of these physical effects will occur simultaneously, additional and unpredictable environmental consequences are possible.

1. Temperature and light

There would be enormous long-term stresses to ecological systems from any altered patterns of climate. The low temperatures and darkness which are predicted could stabilise the temperature gradient in the lower atmosphere and thus reduce relative humidity and rainfall in many regions[28,29]. Besides the possibility of extended droughts, this could prolong the lifetime of the soot and dust clouds.

The consequences of reduced light and lowered temperatures that persisted for weeks or months would range from severe to catastrophic, depending on the season[23]. The effects on New Zealand would probably be greatest if the nuclear war coincided with the southern spring or summer when most actively-growing plants are especially sensitive to lowered temperatures[39]. Photosynthesis in plants, a process upon which all major food chains are based, would slow down and may even stop. The disruption caused by this single ecological response would be massive[40]. However, without controlled experiments, in which a range of New Zealand plants are subjected to low light and low temperature conditions, the precise effects on New Zealand plants, and hence on animals, will remain largely unknown.

Marine phytoplankton, microscopic plants which are the base of the ocean's food chains are especially sensitive to low light (and increased ultra-violet radiation)[21]. It is predicted[34] that if sunlight at the ocean's surface was reduced to 1% of normal there would be little or no plankton production for many species would die out; much less severe reductions in sunlight would also have major effects on marine life simply by reducing the depth to which light would penetrate and thereby restricting the amount of food produced. The effects would be greatest on marine predators - animals at the top of food chains. No estimates of the likely impacts on the Antarctic environment have yet been published.

Freshwater phytoplankton would also be affected, probably more so because of the additional impact of cold temperatures and the concentration of nuclear pollutants by rainfall into streams. Food chains in freshwater habitats would therefore be disrupted in a similar way to those in the sea.

2. Radioactivity

In addition to immediate deaths caused by local fallout, the long-term effects of ionizing radiation[42] on humans include genetic damage, induction of fatal cancers, growth of cataracts (causing impaired vision or blindness), and sterility[5,13]. Radiation-induced cancers will appear as little as two years (leukemia) or more than 20 years (skin, lung) after the initial exposure. The developing embryo is many times more sensitive to ionizing radiation than adults. Since, with any increased exposure to radiation there is an increased risk of a fatal cancer being induced[43], the disperal of radioactive materials into the Southern Hemisphere would lead to an increased number of radiation-induced cancers.

Other animal species would be affected by radiation; terrestrial mammals are particularly susceptible and sheep and cattle are killed by similar levels of acute radiation exposure to humans[5]. Rodents (rats, mice) are among the mammals most resistant to radiation, while insects in turn, are much more resistant than rodents. Precisely how New Zealand's many unique animal species would be affected is not known.

In general, plants are less affected by ionizing radiation than animals, but there are large differences between plant species. Sensitivity is correlated with stature: tall trees of the forest canopy are the most sensitive, followed by tall shrubs, low shrubs, and ground-hugging plants[44]. Evergreens are more susceptible to radiation damage than deciduous trees (most New Zealand forest trees are evergreen), while young plants are more susceptible than those older. For major crops, the order of sensitivity from most to least is: barley-rye-oats-wheat-maize-groundnuts-sunflower-alfalfa-sorghum-cotton-sugar cane-soyabean-rice; barley is about 25 times more sensitive to ionizing radiation than rice[42]. Crop yields can be significantly reduced even when mortality rates are low[44]; an exposure level which kills only 10% can reduce plant yield by 50%. Most of these results are from experiments using gamma radiation. Effects of beta radiation on plants are little known.

At the ecological level, variations between species in their sensitivity to radiation could disrupt many ecological relationships. Those between predators and their prey are especially likely to be affected and some animals, in the absence of their predators could reach very high numbers (e.g. some rodents and insects)[44]. Fallout products such as strontium-90 and caesium-137, upon entering food chains become increasingly concentrated as they pass from plant to herbivore to carnivore, posing a special risk to meat-eating animals. This effect may be magnified in nutrient-poor environments where more fallout products are incorporated into food chains[44].

So far, research has concentrated on the ways in which radiation affects plants and animals used by man for food or other production.

But quite clearly all plant life and all animal life, whether on land or in water, is at risk.

3. Ultra-violet radiation

One consequence of nuclear war which, in the long term, may be more detrimental than fallout pollutants, is the increase in ultra-violet radiation.

> " ... the effects of increased UV-B (ultra-violet) radiation may be among the most serious unanticipated consequences of nuclear war"[23].

For plants, a doubling of ultra-violet radiation levels would reduce photosynthetic activity, inhibit growth and development, and weaken leaves. Some crops - including corn (maize), pea, sugar-beet, onion, bean, tomato and lettuce - are among the most sensitive plants to ultra-violet radiation. The effect of doubled ultra-violet radiation levels on mammals (including humans) would be to suppress immune systems, increase rates of skin cancer, and induce corneal damage and cataracts leading to blindness[21]. In Hereford cattle, the incidence of 'cancer-eye' is known to increase with both length and intensity of the exposure. Humans may, of course, be able to protect their eyes from direct radiation, or else venture out after dark; but livestock, many birds of prey, and animals active by day would have no such option.

High levels of ultra-violet radiation could confuse insect behaviour and disrupt the navigation of essential pollinators. In the oceans, phytoplankton are affected by increased ultra-violet radiation[21], and experiments suggest that the increase in ultra-violet levels could kill species of surface-dwelling fish[28].

4. Acid rain

If rain with a pH below 5.0 persisted over several months, this would affect both terrestrial and freshwater life. However, changes to soil and water chemistry, such as the concentration of trace elements (aluminium, manganese, zinc) to toxic levels in surface and ground waters would not be long-term. The biological impact would be most noticeable on a range of sensitive plants exposed to direct effects; the acidic pollutants are absorbed through both leaves and roots and young or vigorously growing plants are the most sensitive. High acid levels may cause lesions on leaves, cause a loss of nutrients from the leaves, make the plants more susceptible to disease, or directly kill them[37].

Freshwater life, especially fish, is very sensitive to increases in water acidity; rainbow trout embryos are killed at pH 5.52 at 5°C and pH 4.75 at 10°C making this fish one of the most acid-sensitive species[37]. Brown trout have disappeared from lakes in southern Norway

where the long-term pH of the waters became less than 5.0. Freshwater snails, crayfish and some insects are killed by low pH levels, and biological production is generally lower in acidic waters.

Throughout northern Europe and eastern United States, acid rain resulting from the sulphurous emissions from industrial areas is a particular problem. In Scandinavia and Germany extensive forests are slowly dying as a result of prolonged exposure to acid rains, often the acidity of vinegar (pH 3.0). Fish kills, predominantly of salmon and trout occur after almost every period of heavy rain. Precisely how New Zealand's plants and animals will respond to rainfall of the acidity predicted is not known.

CONCLUSION

This review highlights:

1. The likely effects on plants and animals (including humans) and their ecological relationships, of a nuclear war fought in the Northern Hemisphere, are being increasingly researched and documented. As computer models of climatic and biological relationships are improved, the physical and environmental consequences of a nuclear war are shown to be increasingly devastating and to extend worldwide;

2. Consequences within the Northern Hemisphere are receiving the most attention. The likely effects on Southern Hemisphere life of a northern nuclear war is little researched or understood and most comment is derived by simple extrapolation from predicted Northern Hemisphere events.

3. Most research has centred on the immediate human plight rather than the consequences for the global environment and the life forms upon which humans depend for their survival.

It is apparent that, for communities of plants and animals in both terrestrial and aquatic environments, nuclear war will cause enormous disruption. Ecological relationships are so complex that ecologists cannot anticipate all the likely outcomes. However, extended darkness, reduced temperatures, and high levels of radiation damage would see photosynthesis effectively prevented, food chains disrupted or collapsing thus progressively pushing species after species to low numbers, and then to extinction. The final toll of individuals would be uncountable; the number of species lost could reach the tens of thousands, especially in the tropics[45]. New Zealand would not be immune to many of these consequences.

The pattern and rate of recovery of the environment would be uncertain and unpredictable. Continuing adverse climatic conditions, extensive losses in plant communities, damaging levels of ultra-violet radiation and radioactive substances, would particularly affect higher-level animals (birds and mammals). Species most resistant to radiation (bacteria, fungi, insects and small mammals) could be expected to increase dramatically. The New Zealand environment would inevitably be modified by these events.

POSITION OF THE COUNCIL OF THE NEW ZEALAND ECOLOGICAL SOCIETY

Having reviewed the literature available to it on the likely environmental consequences to New Zealand of a nuclear war occurring in the Northern Hemisphere, the Council of the New Zealand Ecological Society believes that there can be no ideological or military justification for subjecting life on our planet to the events this statement has portrayed. Indeed, the strategic implications of the environmental consequences of nuclear war are now being more widely discussed[46]. As a recent editorial in the journal Science stated:

> "If the analysis of the climatic effects of a nuclear strike is correct, then no nation can make a major nuclear attack, even against an unarmed opponent without committing suicide - without itself receiving punishment as severe as that imposed on its intended victim."[47]

New Zealand is a small, isolated country with very little economic or military involvement in the nuclear or conventional arms race. Despite this isolation New Zealanders have, throughout their short history, made enormous personal and economic sacrifices by fighting in distant wars. They can help again in local, regional, and global forums to reduce and eventually eliminate the threat of nuclear war and promote long-term global security, not just for the human species but for all life on the planet.

Accordingly, this Council considers that the following proposals should be recognised as high priority issues requiring prompt and effective action:

At the personal level

> "Now human survival depends on confronting old prejudices and creating new understanding. The first challenge is clear: it is to break our own silence. Each of us has a role to play in the burgeoning nuclear debate."[48]

What people do as individuals will depend on their particular talents and inclinations. There is, however, an initial obligation to understand, at least in general terms, the complex issues that contribute to the nuclear predicament. Actions that take account of these complexities are more likely to be effective in the longer term. It is important to persist, despite the odds, rather than give in to a sense of hopelessness and apathy.

Inaction and silence is often interpreted as endorsement of the nuclear status quo.[49]

At the scientist level

The Council directs a special plea to its colleagues of the scientific community. It believes that scientists have particular obligations with respect to this issue because:

(i) According to some estimates[50], 500 000 scientists and engineers are working on weapons development and military-related research. Scientists in non-military occupations have a major responsibility to promote policies aimed at preventing nuclear war, and to contribute to the many efforts now directed towards making nuclear disarmament an achievable goal[20].

(ii) Much of the technical information about the nuclear issue lies within the scientific literature. Scientists have greater access to this information than other citizens, and, because of their particular training, a greater opportunity to assimilate and translate it for the wider public.

At the individual level, scientists need to become better informed about nuclear issues and the consequences of nuclear war. Where this relates to their specialist training they can improve the public's understanding of the factual issues - without claiming special authority on political issues. The medical profession has been especially effective in clarifying the medical consequences that would follow the explosion of nuclear weapons[5]. For similar reasons, scientists with an understanding of environmental processes have their particular contribution to make. There is a similar role for scientists of other disciplines. This Council's emphasis on the environmental consequences in no way diminishes the particular interest of human beings in their own welfare. But it is no longer sufficient simply to look at how human society is directly affected. Whole ecosystems, evolutionary products in their own right and upon which humanity is directly dependent, will be affected on a global scale. To date, little research has been directed to these wider issues which is why this statement has had to rely on research prompted by the human predicament.

The scientific community should promote efforts to evaluate the possible consequences of nuclear war. Excellent examples of collaborative international efforts now exist[26], and many of these initatives jointly involve scientists from Third World, Soviet bloc, and Western nations. Practical consideration should be given, as a matter of urgency, to determine how New Zealand scientists could contribute to such efforts. They are well placed, for example, to investigate the responses of temperate agricultural systems to the predicted range of cold temperatures and reduced light levels, and to contribute information needed to model the dynamics of the Southern Hemisphere atmosphere.

This Council does not subscribe to the view that if a nuclear war occurs, the social chaos will be so great that such information will be superfluous.

Rather we hold that such a war, and the nuclear arms race itself, may be prevented by assembling the information to show just how extensive and enduring that chaos will be in the world's natural systems.

At the political level

The proposals recommended above can be successfully implemented only with the practical support and encouragement of all political parties.

In New Zealand, much of the nuclear debate has concerned only our local security. The environmental consequences of nuclear war, as an issue affecting New Zealand's future, should be given wider public exposure through the news media and the education system.

Speaking more specifically to our field of professional expertise, this Council requests that the Government:

(i) supports and finances the direct participation of New Zealand scientists in regional and global efforts to develop a better understanding of the environmental consequences of nuclear war. New Zealand researchers in the biological, agricultural, medical, and physical sciences could make important contributions to existing, and future, international efforts;

(ii) establishes an expert task force, which would utilise expertise from natural, physical, medical and social sciences, as well as agricultural, manufacturing and service sectors, to evaluate the likely consequences for New Zealanders and the New Zealand environment of nuclear war in the Northern Hemisphere. The work and report of the task force could raise public awareness of the issues, stimulate debate over our national options, and promote pertinent research.

This Council also recognises the urgency of greater commitment at the political level to control nuclear weapons and develop realistic proposals aimed at the long-term goal of global nuclear disarmament.

Accordingly, this Council ends its statement of concern by endorsing the resolution which stands in the name of Lord Bertrand Russell and Dr Albert Einstein (the Russell-Einstein Manifesto of 1955), and asks all political parties to develop policies that transform the spirit of that resolution into reality[51].

The 1955 RUSSELL-EINSTEIN RESOLUTION

"In view of the fact that in any future world war nuclear weapons will certainly be employed, and that such weapons threaten the continued existence of mankind, we urge the governments of the world to realise, and to acknowledge publically, that their purpose cannot be furthered by a world war, and we urge them, consequently to find peaceful means for the settlement of all matters of dispute between them."

NOTES AND REFERENCES

1. A Council report, "A critique of the environmental impact report on the proposed utilisation of South Island beech forests to the Officials Committee for the Environment" was released on 10 April 1973. An abstract of the report and list of recommendations appeared in Proceedings of the New Zealand Ecological Society, Vol. 20 (1973), pp 155-156 (1973).

2. An ecological approach to New Zealand's future. Compiled by R.A. Fordham and J. Ogden, 1974. Supplement to Proceedings of the New Zealand Ecological Society, Vol. 21, 32pp.

3. Submission to the "Royal Commission to inquire into and report upon nuclear power generation in New Zealand", 1977, 22pp.

4. Nuclear arsenals

   "In the 1960s, aggregation or world nuclear weapons of an explosive power of 400 megatons (one megaton (MT) = 1 000 000 tons of TNT equivalent, one kiloton (kT) = 1000 tons of TNT equivalent), was thought to ensure deterrence by Mutually Assured Destruction (MAD) of both the USA and the USSR essential targets."[5]

   By 1980, the world nuclear arsenals had risen to an explosive yield that was equivalent to 11 000-20 000 megatons of TNT[6]. The figure that is often quoted is 12 000 megatons, which represents an explosive power one million times that of the single bomb that devastated Hiroshima. The number of weapons in existence in 1981 was estimated at 37 000-50 000.[6] These were roughly categorised according to use as "strategic", "theatre", or "tactical".[7]

   In almost ludicrous contrast to these modern stockpiles, the total explosive force of bombs expended during World War II was equivalent to 3-4 megatons. It is difficult to comprehend the quantitative and qualitative differences these enormous changes in potential destructive power mean in both military and non-military terms. Certainly the indiscriminate, annihilating power of present nuclear arsenals has forced a re-analysis of their military usefulness. Robert McNamara, former US Secretary of Defence, wrote in 1983:

   "I do not believe we can avoid serious and unacceptable risk of nuclear war until we recognise - and until we base all our military plans, defence budgets, weapons deployments and arms negotiations on the recognition - that nuclear weapons serve no military purpose whatsoever."[8]

   The absence of nuclear war since 1945 is no guarantee that nuclear war will not break out within our lifetimes. Two separate factors give cause for concern; their respective likelihoods are not estimated here. Firstly, no nuclear weapons system can be regarded as totally fail-safe. Accidents involving nuclear weapons have already occurred; some have been serious.[9] As the number of weapons increases, and as more complex command-communications systems are introduced, the likelihood of accidental use of nuclear weapons will increase. Secondly, the possibility, however small, of a political/military miscalculation starting a nuclear war must be accepted. The spread of nuclear weapon capabilities to more and more countries clearly magnifies this threat and increases the number of incidents which could cause a nuclear war.[10]

5. The medical effects of nuclear war. 1983. John Wiley and Sons. (The Report of the British Medical Association's Board of Science and Education.)

6. Rough estimates of world nuclear arsenals as at 1980:

Nation	'Central strategic'	Other systems	Total weapons
Number of warheads -			
USA	9,000-11,000	16,000-22,000	25,000-33,000
USSR	6,000- 7,500	5,000- 8,000	11,000-15,000
UK	NA	NA	200- 1,000
China	NA	NA	<300
France	NA	NA	<200
			37,000-50,000
Explosive yield (megatons) -			
USA	3,000- 4,000	1,000- 4,000	4,000- 8,000
USSR	5,000- 8,000	2,000- 3,000	7,000-11,000
UK	NA	NA	200- 1,000
China	NA	NA	200- 400
France	NA	NA	100
			11,000-20,000

NA = not applicable.
Figures for USA and USSR rounded to nearest thousands, and for other nations to nearest hundreds. Based on open literature including SIPRI Yearbook 1980 and The Military Balance 1979-80. Source: Nuclear weapons. Frances Pinter, London, 1981, Table 1, p.27.

7. Distinctions are not clear cut, but are roughly as follows. "Strategic" nuclear weapons are those of long range (7,000-11,000 km) and usually large yield (but ranging from 40 kilotons - 20 megatons), aimed at city, industrial or strategic weapons system targets in the USA and USSR. "Theatre" nuclear weapons, largely based in Europe, are of medium range (1,000-5,000 km) and medium yields. They are also regarded as a sub-category of tactical nuclear weapons. The other "tactical" weapons or "battlefield" nuclear weapons have shorter range (20-110 km) and lower yields. However, yields of "tactical" weapons can be less than one kiloton to over one megaton. The tenuous distinction between these classes of nuclear weapons has become further blurred with the development of Pershing II, cruise missile, and SS-20 systems plus some weapons carried by submarines and bombers.

8. Foreign affairs Vol.62 (1983), p.59

9. Accidents involving USA nuclear weapons are classified by the Pentagon as "Broken Arrows" (serious), "Bent Spears" (less serious), or "Dulled Swords" (minor). The Stockholm International Peace Research Institute (SIPRI) estimated 33 serious accidents involving USA nuclear weapons before 1968 and a total of about 125 serious and minor nuclear accidents between 1945-1976. In addition there have been British, French, and Soviet accidents for which data are not so readily available, but SIPRI has estimated a minimum of 12 before 1968. Quoted in Defended to death (Cambridge University Disarmament Seminar), edited by G. Prins, 1983. Penguin Books.

10. Nuclear nightmares: An investigation into possible wars. Nigel Calder, 1979. Penguin Books (1981).

11. The effects on humans
Leaving aside the environmental consequences for the moment it is fair to say that the short and long term costs for humanity alone, in death and suffering, are almost beyond comprehension. The number of dead would exceed all deaths from all wars in human history[12]. The magnitude of the immediate deaths and serious injuries from blast, fire, and radiation would overwhelm medical facilities in the countries under direct attack[5,13]. Many of the initial survivors in these countries would die from the delayed effects of radiation, as well as from infectious disases like cholera, tuberculosis, and dysentery[12]. Uncontrollable outbreaks of plague could greatly increase fatalities[14].

In addition to physical injuries, the survivors would also be under immense psychological stress. The experience of Hiroshima and Nagasaki suggest that many people would be incapable of organised activity[15]. A study in USA[16] showed that even two years after a local natural disaster (flooding) survivors showed despair, apathy and depression related to the complete destruction of the social fabric of their community. When discussing the psychological shocks facing the survivors of a major nuclear attack on the UK, the Report of the British Medical Association[5] concludes:

> "... there is no doubt that experience of conventional warfare is irrelevant (their italics) to the scene that would confront whatever survivors remained after a major nuclear attack."[17]

That same report comes to the following conclusion on the long-term prospects for survivors in the UK:

"It is inaccurate and misleading to suggest that after a nuclear attack on the United Kingdom there would be a return to a rural civilisation of two centuries ago. The Working Party believes that there would be an increase in infant mortality, communicable diseases due to infections, and deficiency diseases caused by inadequate nutrition. The UK no longer possesses the skills or primitive technologies which allowed our predecessors an existence with some measure of comfort. The skills of the 20th century do not permit a return to that style of life after a nuclear attack."

Human survivors in countries that were not directly affected by the nuclear exchange would face starvation, psychological and social traumas, and added biological stresses from radioactive fallout, damaging levels of ultraviolet radiation and high risk of disease epidemics[18]. Normal patterns of trade and commerce would disappear. Destruction and long-term effects would be more serious in the Northern Hemisphere. A French economist suggests:

"There would be no reason for economic progress as we know it, no will to innovate, invest or invent ... we would be returned to a sort of economic dark ages."[19]

12. The "Ambio" study was contained in a special issue of the journal Ambio, published by the Royal Swedish Academy of Sciences (Volume 11, Nos 2-3, 1982). All papers were later reproduced in book form; The aftermath : the human and ecological consequences of nuclear war. Edited by J. Peterson, 1983, Pantheon Books, New York.

This study assumed that a global nuclear war would break out in June 1985 and lead to the detonation of 5742 megatons of nuclear weapons, 5569 megatons in the Northern Hemisphere and 173 megatons in the Southern Hemisphere, over a short period of time.

The predictions of human casualties were that in the Northern Hemisphere, 750 million people would be killed outright and 340 million seriously injured. Further predictions included the inducement of 5.4 - 12.8 million fatal cancers among the survivors, 17-31 million people rendered sterile and 6.4 - 16.3 million children born with genetic defects during the subsequent 100 years.

13. Last aid : the medical dimensions of nuclear war. Edited by E. Chivian, S. Chivian, R.J. Lifton and J.E. Mack. 1982. W.H. Freeman and Co., San Francisco.

14. Infection and communicable diseases. H.L. Abrams in : The final epidemic. Edited by R. Adams and S. Cullen, 1981. The University of Chicago Press, Ill. pp. 192-218.

15. Hiroshima diary : The journal of a Japanese physician, August 6 -

September 30, 1945. M. Hachiya, 1955. Tokyo, Asahi Shimbursha.

16. Human meaning of total disaster : The Buffalo Creek experience. R.J. Lifton and E. Olsen. Psychiatry. Vol.39 (1976). 1-18.

17. Reference 5, p.108.

18. Life after nuclear war. A.M. Katz, 1982. Ballinger Publ. Co. The book describes the economic and social impacts of nuclear attacks on the United States. It contains much useful material on psychological, political, and institutional effects but pre-dates the climate/environment findings reported here and therefore under-estimates certain impacts, especially food production.

19. Economic consequences: back to the dark ages. Y. Laulan, 1982. Ambio, Vol. 11 (1982). pp 149-152. The author is Chief Economist at Societe Generale, the largest French bank. He was chairman of NATO's Economic Committee.

20. Scientists, the arms race and disarmament. Edited by Joseph Rotblat, 1982. (A Unesco/Pugwash Symposium.) Taylor and Francis Ltd, London. Ch.8 summarises the activities of scientific organisations working against the arms race. Chs 9 and 11 deal with social responsibility issues.

21. Long-term worldwide effects of multiple nuclear-weapons detonations. U.S. National Academy of Sciences, 1975. Washington D.C.

22. Nuclear winter: global consequences of multiple nuclear explosions. R.P. Turco et al. Science, Vol.222 (1983), pp 1283-1292.

23. Long-term biological consequences of nuclear war. P.R. Ehrlich et al. Science, Vol.222 (1983),pp 1293-1300.

24. Report on the status of studies on the atmospheric effects of nuclear war with special reference to effects on the southern hemisphere. A.B. Pittock, 1984, CSIRO Division of Atmospheric Research, Australia.

25. Global atmospheric effects of massive smoke injections from a nuclear war: results from general circulation model simulations. C. Covey et al. Nature 308 (1984), pp 21-25.

26. The study is by SCOPE (Scientific Committee on Problems of the Environment), a standing committee of the International Council of Scientific Unions (ICSU) which is composed of most national Academies of Science and many international scientific unions or associations.

27. North America after the war. P.R. Ehrlich, 1984. Natural History, 3/84, pp 4-8. This scenario explores a "plausible worst case" of the ecological consequences of nuclear war for 3000 years after its outbreak.

28. The atmosphere after a nuclear war: twilight at noon. P.J. Crutzen and J.W. Birks. Ambio, Vol.11 (1982), pp 114-125.

29. Global climatic consequences of nuclear war. Simulations with three-dimensional models. S.L. Thompson, V.V. Aleksandrov, G.L. Stenchikov, S.H. Schneider, C. Covey and R.M. Chervin, 1984. Ambio (in press).

30. Some changes in the atmosphere over Australia that may occur due to a nuclear war. I.E. Galbally, P.J. Crutzen and H. Rodhe. In : Australia and nuclear war. Edited by M. Denborough, 1983. Croom Helm, A.C.T.

31. 'Acid rain' is rain containing high levels of dissolved oxides of nitrogen and sulphur. These gases enter the atmosphere mostly from volcanic eruptions or the industrial burning of fossil fuels. Acidity is measures by the pH scale; a value of 7.0 is assigned to neutral solutions such as distilled water, but as values decline from 7.0, this indicates increasing acidity. Normal rainfall in New Zealand is about pH 5.6, vinegar pH 3.0 and battery acid pH 1.0. The pH scale is logarithmic; a decrease from pH 4.0 to pH 3.0 represents a 10-fold increase in acidity. Battery acid is 100 times more acidic than vinegar. Acid rain in Europe frequently exceeds the acidity of vinegar.

32. The atmospheric effects of nuclear war. A.B. Pittock. In : Australia and nuclear war. Edited by M. Denborough, 1983. Croom Helm, A.C.T.

33. 'Half-life' is the period of time in which the activity of a radioactive substance falls to half its initial value.

34. The impact on ocean ecosystems. A.H. Seymour. Ambio, Vol.11 (1982) pp 132-137.

35. Effects on global supplies of freshwater. K.G. Wetzel. Ambio. Vol.11 (1982) pp 126-131.

36. When polychlorinated biphenyls (PCB's) burn, for example, the release of toxic polycyclic chlorinated organic compounds can amount to 0.1 percent by weight. In the USA, more than 300,000 tons of PCB's are in use in electrical systems[22].

37. Acidic deposition : effects on aquatic ecosystems. P.J. Dillon, N.D. Yan and H.H. Harvey. Critical reviews in environmental control. Vol.13 (1984), pp 167-194.
The menace of acid rain. F. Pearce. New Scientist. Vol.95 (1982), pp 419-424.

38. Changes in ozone content from a nuclear explosition. V.N. Petrov. In : Last aid : The medical dimensions of nuclear war. Edited by E. Chivian, S. Chivian, R.J. Lifton and J.E. Mack, 1982. W.H. Freeman & Co., San Francisco.

39. "Exposure of rice or sorghum to a temperature of only 13°C at the critical time can inhibit grain formation because the pollen produced is sterile. Corn and soybeans ... are quite sensitive to temperatures below about 10°C." From ref 23, p.1296.

40. An historical precedent exists for the disruptive effects of small temperature declines. In 1815, the eruption of Mt Tambora in Indonesia released immense quantities of dust into the lower atmosphere which slowly spread northwards. This produced an average temperature decline of only about 1°C but it also caused a series of hard freezes throughout Europe and North America in the summer of 1816[41]. Corn crops were reduced by more than 50%, growth of pasture grasses slowed and the Canadian wheat crop was heavily affected.

41. The year without a summer. H. Stommel and E. Stommel. Scientific American. Vol 240 (1979), pp 134-139.

42. Ionizing radiation is caused by several types of radioactived emission which are released during the decay (to a stable state) of radionuclides (radioactive isotopes). Types of emission are: alpha and beta particles (limited power of penetration); gamma-rays (highly penetrating, like X-rays); neutrons (highly penetrating, and can cause secondary ionizing radiation on interaction with other atoms); protons; X-rays.

43. Report to the General Assembly on Sources and Effects of Ionizing Radiation, 1977. U.N. Scientific Committee on the Effects of Atomic Radiation. UN E.77.IX.1.

44. The biotic effects of ionizing radiation. G.M. Woodwell. Ambio, Vol.11 (1982), pp 143-148. A general account of radiation ecology is contained in Fundamentals of ecology, E.P. Odum, 1971 (pp 451-467). W.B. Saunders & Co.

45. Tropical ecosystems contain the richest, most diverse assemblages of plants and animals on earth. Two-thirds of all species of plants, animals and micro-organisms known to science live within 25° latitude of the equator[46] and there remains thousands of species yet to be described scientifically. Many tropical plants do not have the ability to become dormant during periods of unfavourable temperatures and are unlikely to tolerate extended freezing temperatures at any season.
"If darkness or cold temperatures, or both, were to become widespread in the tropics, the tropical forests could largely disappear."[23]

46. Nuclear war and climatic catastrophe : some policy implications. C. Sagan, 1983. Foreign affairs, Winter 1983/84 : 257-292.

47. Mutual deterrence or nuclear suicide. H.A. Simon. Science, Vol.223, (1984) No. 4638, p.775.

48. Taking Australia off the map. J. Falk, 1983. Penguin Books, Australia.

49. Crisis over cruise. P. Webber, G. Wilkinson, and B. Rubin, 1983. Penguin Books.

50. Study on the Relationship between Disarmament and Development. Report of the Secretary-General, United Nations Document A/36/356, 1981. The 500,000 scientists and engineers working in military-related research is estimated to represent between 20-25% of the entire scientific research workforce.

51. The final part of the Russell-Einstein Manifesto which was issued in London on 9 July 1955. The manifesto, later endorsed by many individuals and groups, was initially signed by several Nobel-Prize Laureates including Max Born (Physics), P.W. Bridgman (Physics), J.F. Joliot-Curie (Chemistry), H.J. Muller (Physiology and Medicine), L. Pauling (Chemistry), H. Yukawa (Physics).