New Zealand After Nuclear War

THE BACKGROUND PAPERS

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BACKGROUND PAPER 4

MEETING NEW ZEALAND'S FOOD NEEDS

by

Diane Hunt

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).*

PART A: FOOD PRODUCTION

BACKGROUND INFORMATION

New Zealand's food production sector is oriented primarily toward the export of the large amount which is surplus to the needs of our own population (3.3 million people at the end of 1985). Around 80% of the lamb we produce is exported, while for cheese the figure climbs as high as 95% in some years. For other commodities the proportion is somewhat lower (e.g. beef, less than 50%).

In 1985 the total area of farms in New Zealand was 21,376,800 hectares; this represented 80% of our total land area (26.8 million hectares). The major land use in New Zealand is pastoral farming (10 million hectares) which supports the wool, meat (beef and lamb) and dairy industries. Other important production systems are cereal cropping and horticulture (together occupying 0.5 million hectares). Residual lands totalling 11m hectares are unimproved tussock and other land holdings. Goat, deer, pig and poultry farming also contribute to food production.

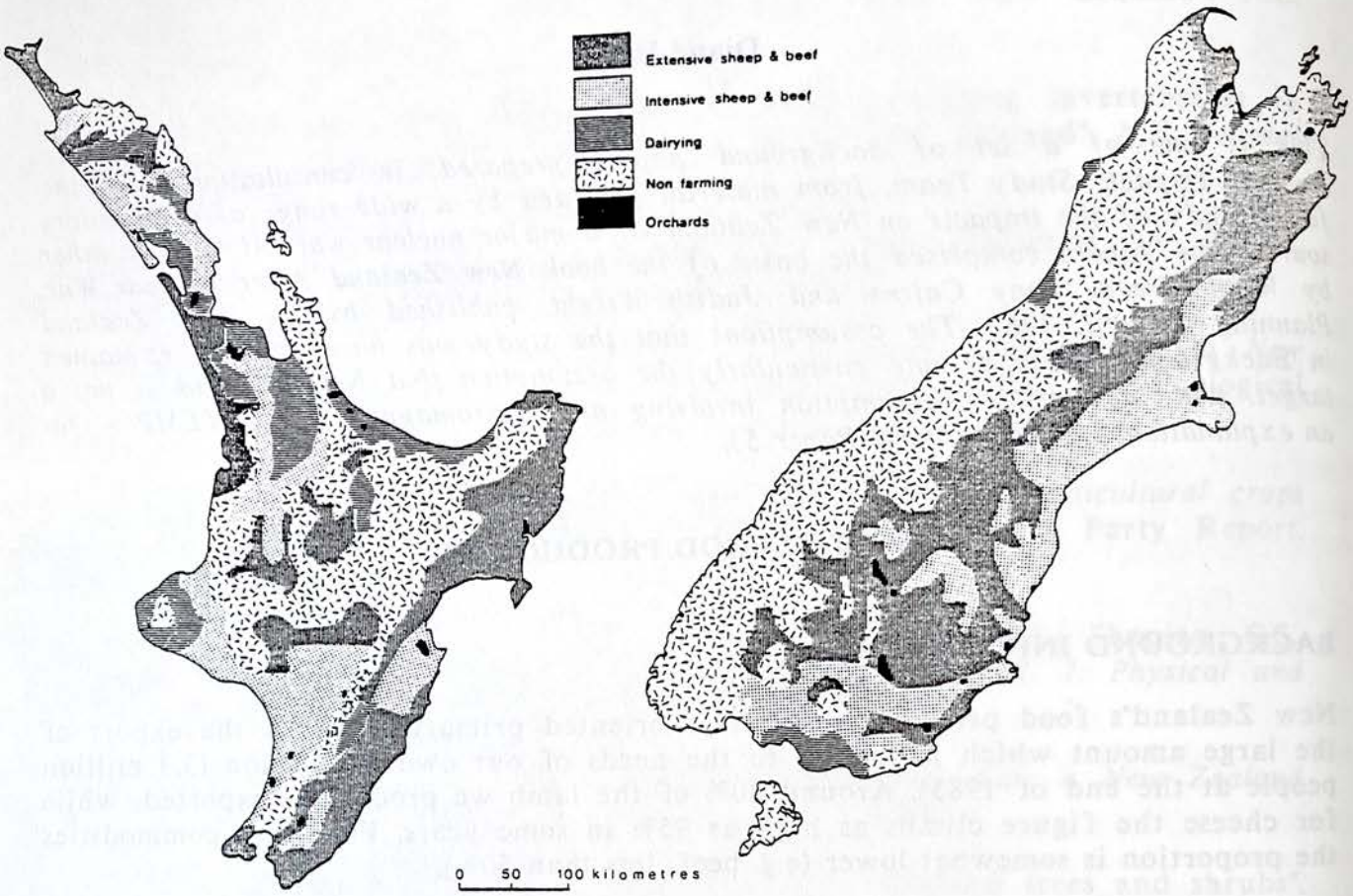
Animal numbers

New Zealand farms have following numbers of live animals:

Sheep	66.5 million
Beef cattle	4.8 million
Dairy cows	3.4 million
Poultry	3.5 million
Pigs	470,000
Deer	420,000
Goats	376,000

Source: MAF 1987 and NZ Department of Statistics.

Location of major farming activities in New Zealand (from Wards, 1976, in Smith & McChesney, 1979)



Meat industry

In the year to September 1986, 45 million animals were processed by the meat industry. These included:

Lambs, mutton and hoggets	42.08 million
Beef cattle	1.88 million
Calves	.936 million
Pigs	.842 million
Goats	16,000

The majority of these (excluding pigs) were slaughtered for export. The meat and carcass by-products industry is the largest single contributor to New Zealand's export income and earned around 21% of total income in the year to June 1985.

Dairy industry

The dairy industry is large and efficient, having by world standards a high output per unit and low production costs. The dairy product industry further processes around 90% of liquid milk production. Over 80% of the products of that industry are exported (see Part B). For the year to 31 May 1987, 8 billion litres of milk

was produced, but production is expected to drop to under 7 billion litres in 1987. (Source: NZ Agricultural Statistics 1987.)

Fish

New Zealand's coastal waters are fished by domestic vessels (2,519 registered in 1985), while the deeper waters are fished by foreign chartered and foreign licensed vessels as well as domestic vessels. Of the 3200 people working in the domestic fishing industry, 3000 are independent contractors. The only significant commercial freshwater fishery is the eel fishery (1503 tonnes in 1985). Oysters are farmed north of Auckland and mussel farming occurs primarily in the Marlborough Sounds. Salmon farming is being developed in the South Island. The total fish catch in 1985 was just under 400,000 tonnes. This includes the output from mussel and oyster farming (11,554t in 1985).

Cereals

The following table gives the areas and yields of New Zealand's principal cereal crops to 30 June 1986 (1987 estimates are included in brackets).

Crop	Area (hectares)	Yield (tonne)	Primary Growing Areas
Wheat	98,000 (82,000)	392,000 (310,000)	Aorangi,Canterbury, Central Otago, Southland Manawatu,Wanganui
Oats	12,000 (19,000)	48,000 (75,000)	Aorangi,Canterbury, Otago, Southland
Barley	130,000 (98,000)	550,000 (400,000)	Canterbury
Maize	22,000 (22,000)	210,000 (200,000)	Waikato, East Cape, Bay of Plenty
Peas	26,000 (43,000)	60,000 (118,000)	Canterbury, Aorangi

Source: Ministry of Agriculture and Fisheries, Agriculture Review Committee Estimates, *New Zealand Agricultural Statistics*, 1987.

Some barley and maize is exported unmilled, although New Zealand also imports some cereals. In the year to June 1986 this included 71,552 tonnes of wheat, 0.3t of

barley and 10t of maize, 822t of millet and 9,639t of rice (source: New Zealand Department of Statistics).

Horticulture

New Zealand is basically self-sufficient in vegetables and fruit, although some tropical crops (e.g. taro, bananas, pineapples) are imported. The horticultural industry has, over the past decade, been in a state of rapid growth and diversification and is increasingly export-oriented. Temperate zone fruits such as apples, stonefruit and berryfruit are grown in the south of the central North Island and in the South Island. In the north of the North Island more subtropical fruits, such as citrus and kiwifruit, are produced.

In the year to 31 March 1986, New Zealand exported 411,000 tonnes of fresh and frozen horticultural products (excluding canned products). These products earned $509 million which increased to $750 million in the 1986 financial year. (Source: Ministry of Agriculture and Fisheries.)

The growth anticipated in the horticultural sector is illustrated by the projection that kiwifruit production will reach 360,000 tonnes by 1994/95, with 80% of this production being exported (unpublished MAF estimate).

The following table gives estimates for horticultural production in the 1985/86 year.

Crop	Production (tonnes)
Apples	276,594
Berryfruit	18,000
Citrus and subtropical fruit (excluding kiwifruit)	28,500
Hops	450
Kiwifruit	93,562
Onions	60,000
Pears	18,034
Potatoes	295,000
Tobacco	1,700
Stonefruit	36,000
All other fruit	300,000

Source: Ministry of Agriculture and Fisheries.

Wine

The New Zealand wine industry now has about 4,500 ha of winegrapes, producing at around 13 t/ha about 58,500 tonnes of grapes, yielding about 44.5 million litres of wine. The 1984/85 consumption was 13.2 litres per head. About 80% is table wine, the remainder fortified. About 80% of the crop is grown by contract growers, the majority in Poverty Bay and Hawkes Bay, followed by Marlborough and Auckland. In 1984/85, about 3.9 million litres were imported, or about 6% of the total consumption. (Figures provided by R. Smart, MAF, Ruakura.)

Seeds

New Zealand currently imports the majority of its vegetable seeds. The following table indicates the percentages produced in New Zealand.

Vegetable	Approx. percentage of seeds produced in New Zealand
Broccoli	1%
Cabbages	5%
Carrots	1%
Cauliflower	10%
Fresh tomatoes	10%
Kumara	100%
Lettuce	1%
Onions	95%
Potatoes	100%
Processing beans	Nil
Processing peas	100%
Processing tomatoes	Nil
Pumpkin (grey)	100%
Sweet corn	90%
Zucchini	Nil

(Sources: Brian Freeman, *Yates*, and Clive Westbury, *Webling & Stewart*, and MAF)

Some come from Australia (e.g. 90% of lettuce and 80% of cauliflower seed).

New Zealand currently produces and exports a range of herbage seeds including white and red clover, perennial ryegrass and other grasses. Smaller quantities of brassica seeds (such as kale, swede and turnip used for growing animal feed) and seeds for trees, flowers and vegetables are also exported. Peas are another important seed export. To the year ended 30 June 1986, the total seed export was 13,290 tonnes (value $21.7 million), including 6,000 tonnes of herbage seed and 6,500 tonnes of peas (source: Official Seed Testing Station, Annual Report 1986, MAF). Thus New Zealand is essentially self-sufficient in herbage seeds, although small quantities of clover and grass seeds are imported (e.g. in the year to June 1986, 65t of subterranean clover seed was imported from Australia (Department of Statistics). Some of the cereal crops we import are used as seed.

Fertilisers

Fertiliser requirements for pastures (including allowances for animal health) are:

(a) in large quantities (15-20 kg of elements/ha): phosphorus, sulphur, potassium, calcium and magnesium;

(b) in small amounts (few kg/ha): cobalt, selenium, molybdenum, boron, copper and zinc. For horticultural crops and cereals nitrogen is also needed every year (at about 50 kg/ha) and phosphorus and potassium in larger quantities than for pastures.

New Zealand's ammonia-urea plant produces 155,000 tonnes a year, of which 50,000 tonnes (a third) is used locally as nitrogenous fertiliser. Most fertilisers or raw materials are, however, imported. In 1985 New Zealand spent $93.7 million on imported rock phosphate, most of which came from Nauru and Australia, and a further $10.9 million on manufactured phosphatic fertilisers (NZ Yearbook 1986:661). Other fertilisers, such as superphosphate, are made locally from imported raw materials.

The amounts of raw materials used by New Zealand's fertiliser works in the manufacture of fertilisers or sold directly from works without further processing in 1985 were as follows:

Fertiliser type:	**Tonnes**	**Country of origin of raw materials**
Rock phosphate	1,030,560N	Nauru, Christmas Island (these two sources may cease in 5 years time), USA, Jordan and Israel
Sulphur	235,756	Canada (with 1294t coming from local deposits near Lake Rotokawa)
Lime	31,099	Locally produced
Serpentine rock	48,681	Locally produced
Di-ammonium phosphate	44,339	Imported
Triple super	14,832	Canada
Potassium sulphate	945	Canada (but local resource)
Potassium chloride	206,507	Canada (but local resource)
Ammonium sulphate	43,804	Canada
Calcium ammonium nitrate	616	
Urea	31,083	Locally produced
Calcined magnesite	1,488	93% imported
Other major fertiliser compounds	51,700	
Trace elements, compounds of:		
Boron	1,290	USA (no local resource)
Cobalt	86	Zaire, Central Africa, probably through USA and UK (no local resource)

Copper	2,238	Last mined in NZ in 1974
Magnesium	1,880	No local resource
Manganese	176	Potential local resource
Molybdenum	52	No local resource
Selenium	325	Canada, Sweden (no local resource)
Zinc	947	Locally produced
Iron	85	Presently imported but local resource

(Sources: S.S.S. Rajan, Ruakura Soil and Plant Research Station, MAF 6-monthly fertilizer survey, and George Munro, Mining Division, Ministry of Energy.)

As can be seen from the above list, many of the raw materials are imported from or through the Northern Hemisphere.

Pesticides

Insecticides are now used to a very limited degree in pastoral agriculture, compared to the 1950s and 60s when cheap, persistent organochlorine insecticides (such as DDT) were used widely. The relatively low profit-margins of pastoral farming, decrease in pest numbers (e.g. grass grubs) from a peak in the 1960s and the high cost of most currently available insecticides largely preclude their use. Control of pasture pests relies mainly on alternative approaches, such as resistant plants, farm management practices, and naturally occurring biological controls.

Insecticides (and fungicides) are used more extensively in arable farming, e.g. cereal production, and are used widely and in relatively large quantities (on a per hectare basis) in horticulture, primarily to ensure high quality, unblemished fruit. Herbicide use tends to follow a similar pattern.

Insecticides, fungicides and herbicides are imported to supplement local manufacture.

	Imported value $ million (to June '86)	Domestic manufacture $ million (1984/85)
Insecticides	4.477	9
Fungicides	7.146	2
Herbicides	2.610	32
Total	14.233	43

Source: Department of Statistics.

Animal vaccines

There are 3 manufacturing plants for animal vaccines in New Zealand; these are Coopers Animal Health Limited (Upper Hutt and Auckland) and Arthur Webster Limited (Hamilton). New Zealand is presently self-sufficient in animal vaccines, and produces a surplus for export. The vaccines rely on growth media, essential components of which (aminoacids, alum and vitamins) are not produced in New Zealand. Stocks of ingredients are sufficient for 2-3 months of animal vaccine production.

LIKELY IMPACTS OF NUCLEAR WAR

Immediate Impacts

The impacts of reduced light and temperature on food production systems would become evident over the first six months rather than immediately. Shortages of imported inputs to agriculture (fertilisers, seeds, pesticides etc) would not make themselves felt until existing stocks were depleted. Little stock is killed during July and other winter months, milk production is low and few crops are grown at that time. Thus for an interim period of a few weeks to a month, farmers would be able to postpone many decisions regarding production.

In the case of an EMP over New Zealand disabling electricity supply, immediate impacts would be more severe. Many of the irrigation systems would cease to function (141,167 ha of farms used spray or sprinkler irrigation in 1985), although this would be much less important in winter than during spring or summer. Milking machines on dairy farms would no longer operate, and in the absence of sufficient labour for hand-milking, production of milk would fall rapidly as cows were dried off. Within two weeks all but hand-milked cows would be dry. Potential production losses could be as high as 80% unless the workforce increased to 5 to 6 times the present levels. Any milk in farm storage or produced over that time would presumably have to be dumped because on-farm chilling facilities would not work. All electrical equipment would be similarly affected (electric fences, heated hen batteries, heated winter glasshouses, shearing machines).

More relevant, perhaps, than physical effects in the case of an EMP would be the psychological effect on farmers and horticulturalists who found themselves without any telephone, radio or TV communication with the rest of New Zealand. The incentive to continue with normal routines of stock and/or crop management would disappear with the overseas markets and the poverty of the newly unemployed local market. Rationales for continuing to work would include the need to feed dependants, hope for the future return of overseas markets and the reassurance derived from familiar patterns of work which had been profitable in the past.

Because the majority of New Zealand's primary production is exported, in the short term there would be a large surplus of food. Frozen meat in storage awaiting export would instead be available for home consumption, and the country would be faced with numbers of live animals far in excess of its own needs (66.5 million sheep, plus many millions of lambs that would be born the next spring). In July, fruits (apples, kiwif .it and berryfruit) and all varieties of vegetables harvested in the previous season would be in cool-stores. There would be large supplies of those which awaited export (e.g. apples, kiwifruit.) Some food crops would still be in the ground (potatoes, winter brassicas such as cabbages and cauliflowers, leeks etc) and these would be safe for eating (in the absence of

high levels of fallout) although some reassurance of the public might be needed.

In the case of an EMP, the storage life of frozen meat and other products (such as dairy, fruit) in cool stores would be greatly reduced. The absence of refrigeration would, on a smaller scale, affect private homes also. Food poisoning might be a problem, and the large-scale disposal of rotten meat, fruit and vegetables might create severe public health dangers.

Those in the animal health servicing industry could be deluged with samples from people wanting to know if their animals have been affected by radiation. Much of this work is reliant on electronic instruments, which would be rendered inoperative by an EMP. The National Radiation Laboratory could not cope with a large increase in demand for the testing of samples.

Impacts at six months

Vegetables

A fall in temperature of 3°C and cloudy conditions would have some effect on the time of maturity of vegetable crops, leading to some shortages in the late spring and early summer. Summer crops (tomatoes, peppers etc) would make slow growth; tomatoes in the South Island would be affected in their ripening. As a consequence, production of vegetables in glasshouses or plastic tunnel houses (cloches) could become more important; they not only produce crops more quickly, but are also safer from possible future fall-out. Furthermore, glass will filter out the higher levels of ultra-violet light, which would stunt the growth of some vegetable crops (peas, onions, beans, tomatoes).

Vegetable production would not be affected over this period by shortages of pesticides or of seed. Fuel may be a greater problem; fuel use is high in vegetable production because of cultivation needs. Irrigation is also required over the summer months, and such systems are fueled by either diesel or electricity and often depend on the availability of imported spare parts. Thus the occurrence of an EMP would render many irrigation systems inoperative. The effect of this on vegetable production over the summer following the war would depend on rainfall. Widespread drought may be associated with a nuclear winter effect, according to the work of Pittock et al (1986), who predict a possible drop in rainfall of up to 50% in Southern Hemisphere latitudes (See also Potter et al, 1986).

Fruit

For citrus and subtropical fruits (such as tamarillos and kiwifruit), the drop in temperature would delay flowering and lengthen the blossom period. Thus the growing season would be shortened and fruit may not mature. The reduction in light would also lower total crop and delay maturity. For example, a reduction of 1°C average temperature in spring delays flowering in kiwifruit by up to seven days and the blossom period is then up to three weeks late (P. Sale, MAF).

Pollinating insects may be affected; those which fly only in fairly bright sunlight, and are sensitive to colder temperatures, would perform less pollination. Bees would be affected by drops in temperature and the presence of aerial pollutants but probably not by increases in UV light levels. Horticulturalists might have to pollinate their crops by hand.

Drought and a shorter frost-free season would also affect fruit production.

Certain plant diseases are likely to become less of a problem with falling temperatures, and more severe frosts might also kill off some insect pests. However, any increase in humidity and rainfall would exacerbate some diseases. Similarly, any increases in ultraviolet levels, or higher radiation levels from nuclear fall-out, would increase disease and pest problems.

Cereals

The effect of the potential climate changes would be to cause a substantial decrease in yields of cereal crops. An initial reduction of 3°C would delay maturity of wheat crops by about 40 days in Canterbury, giving a harvest some time in February or early March. This in itself is not a problem, but combined with a 20% decline in solar radiation would result in a probable decline in yield of about 15%. (Dr P. Jamieson, Crop Research Division, DSIR.) In Southland, where the temperatures are normally lower anyway, a further reduction in temperature might prevent grain crops maturing at all. The occurrence of more frequent or more severe frosts could also delay the formation of mature grain, and could affect seed germination.

In the event of an EMP, spray irrigation systems might be inoperative and irrigated wheat yield thereby reduced by up to 50% (depending on rainfall). If rainfall is lowered as a result of nuclear war,, then severe declines in yield might be expected.

Imports of wheat from Australia would decline, and possibly cease completely. This is potentially a dietary problem because New Zealand is currently not self-sufficient in wheat, and shortfalls in high-quality flour would result.

Pasture production

The effects of temperature decline on pasture growth rates would be more severe in the normally colder areas of New Zealand. For example, it has been estimated that in the Waikato the percentage reduction from normal growth rates in the first spring would be 34% compared with 66% in Southland. Changes in these effects over time are given in Background Paper 3.

The effects are more severe in the normally colder areas of Canterbury and Southland. Any reductions in rainfall would exacerbate these effects.

The complete loss of our export meat trade would render current stocking rates unnecessarily high, at the same time as a decline in pasture production would reduce the carrying capacity of the land for livestock. This reduction in carrying capacity may not matter, given other likely adjustments in the pastoral sector. For example, if new calves are left to drink from the cows (because less milk is needed in the dairy industry) then less grass will be needed to feed those calves.

Animal health

Further reductions in the numbers and health of New Zealand's livestock are likely to be caused by an increased incidence of parasites and diseases. These effects will become more severe in the longer term as vaccines and other imported chemicals become unavailable.

Fish production

The SCOPE study indicated that marine and estuarine ecosystems are very sensitive to reductions in incident light (Harwell et al, 1985). Phytoplankton and zooplankton production drops, and this in turn might be expected to cause a decline in the populations of fish species on which New Zealand's fishing industry depends (time-scale and magnitude of effect uncertain). Falling sea temperatures could cause some changes in fish occurrence. Radioactive fallout would be unlikely to affect ocean fisheries around New Zealand, although problems might arise in estuarine areas and water run-off points.

Agricultural chemicals

New Zealand carries sufficient stocks of most agricultural chemicals to sustain the current season's crop production close to normal levels (Dr I. Harvey, MAF, Lincoln).

At present, herbicides and pesticides are being shipped in constantly, and since most are manufactured in the Northern Hemisphere, these agricultural imports would become increasingly unavailable. If trade with Australia could continue, this effect might be slowed, since some chemical stocks are held in Australia and some basic herbicides manufactured there.

Fuel

Most farm vehicles are fueled by imported diesel. At the time of a nuclear war, New Zealand might have around 135,000 tonnes of diesel in stock (this would be approximately 13% of 1985 requirements of light diesel oil according to M. Foster, Coastal Shipping Co-ordinating Committee, and Department of Statistics. Farm households use 6% of New Zealand's total gasoline and agriculture uses 12% of the diesel. Manufacture of food items is assigned a further 4% of automative diesel (data from *Energy Use in Transport Data Report,* 1986). The exhaustion of diesel stocks would result in a severe burden being placed on the small proportion of petrol-driven farm implements. With rationing, diesel could be made to last longer. New Zealand recently sold off 48,000t of diesel, the national strategic petroleum reserve (NSPR) established in 1981 at the time of the last oil shock ("...the Government could see little reason for continued investment in any NSPR", Minister of Energy Press Release 7/1/87). Harvesting of cereal and grain crops could be disrupted in the absence of a system to ensure that arable farmers have sufficient fuel. Farmers generally have storage for fuel on their farms, although at the very most this would last for 6 months. Larger, more intensive farms generally have less storage in relation to usage.

Egg production would be disrupted by shortfalls in diesel supply and/or loss of electricity supplies, because most eggs are produced in large battery farms. Farms that currently use biogas from chicken manure to operate would be better prepared to survive. Alternative fuels, ethanol, tallow and dairy products could be used to power farm machinery (see Massey University Department of Agronomy Report to the Liquid Fuels Trust Board, No. 2021, "Yields, Costs and Availability of Natural Oils/Fats as Diesel Fuel Substitutes").

Imported food

Tea, coffee, sugar and spices are all imported from the tropics, and in the short term (once existing stocks are depleted) these would probably be absent from our

diet. Trials have shown that tea can be grown in New Zealand and could tolerate a 1-3°C drop in temperature; substitutes such as herbal teas can also be grown here (20t of New Zealand's 7000t requirements are presently grown at Riwaka near Nelson). Sugar could be produced from sugar beet, although the feasibility of doing this may need further study. Honey is a local substitute, although in 1986 New Zealand produced only 10,314t of honey, compared with imports of 180,000t of sugar (NZ Year book 1986, p.87). Cooking oils are primarily imported at present, although there is a local industry based on rape seed, which could be expanded. The industry produced 478t of machine-dressed rape seed (and 380t of linseed) in the year ending December 1985. Rape is also grown as a fodder crop, 25,000 hectares in 1984/85, and a further 10,000 hectares of mixed rape/turnip fodder crop - 73% of these crops were grown in Canterbury, Aorangi and Otago.

Longer-term impacts

Seeds

Seed shortages would become a crucial issue after 1-2 years. New Zealand produces its own "seed" stock for potatoes, onions, pumpkin and kumara (a sweet potato), but almost all seed is imported for cabbage, carrot, lettuce, cauliflower, broccoli and squash and many other vegetables. Production of seeds in New Zealand would take 6-12 months, but it would be difficult to duplicate the hybrids or high-yielding or disease-resistant lines currently used. Even in areas where New Zealand is highly self-sufficient (e.g. cereal seed stock) current lines may prove to be unsuited to the new climatic conditions.

Fruit trees

New material for propogation of nursery and fruit trees would no longer be available from overseas, but existing tree stocks should be sufficient.

Fertilisers

It has been estimated that pasture production would decrease by up to 10% in two years following loss of fertilisers containing phosphorus, sulphur and potassium. From then on, a sharper decline in production could be expected. Cereals and horticultural crops are also dependent on potassium and phosphorus, and in the longer term a decline in production of up to 50% might occur. (Figures from S.S.S. Rajan, Ruakura Soil and Plant Research Station.)

Nitrogenous fertilisers are particularly important in vegetable production. The ammonia-urea plant can supply all of New Zealand's needs for nitrogenous fertiliser, although that plant may in turn may be susceptible to breakdown if key technological components can no longer be supplied from overseas (see Background Paper 6).

Pesticides

Pesticide use is currently high in fruit and vegetable production, and existing stocks would be depleted within 1-2 years, resulting in a marked decline in crop yields and fruit quality. In the case of fruit, where exporting would have ceased, the reduced output would probably be sufficient and the demand for unblemished fruits would no longer be critical. For vegetables, a fall-off in yield could be compensated for by increased plantings.

Machinery and parts

Supplies of new horticultural and agricultural machinery and parts would no longer be available from overseas. However, by the time the potential for repairs was exhausted, lack of fuel or lubricants might be the limiting factor.

In the fishing industry, almost all gear and machinery is imported and those things that are manufactured in New Zealand rely almost entirely on imported content. These essential items include engines, compressors for freezing equipment, stainless steel propeller shafts, electronic equipment such as radar and sonar, and all fish netting, as well as lubricating oils and diesel fuel. Unless these resources were controlled and managed carefully, shortfalls would occur very quickly after cessation of imports.

Animal health

Parasitism and disease among New Zealand livestock would become a severe problem in the long term. Imported anti-worm chemicals called anthelmintics are currently the only effective means of parasite control, and without these, uncontrolled parasitism in sheep may result in mortalities of 20-40% and decreased growth of survivors of up to 30%. An estimated 33% of sheep production depends on anthelmintics (Dr R.V. Brunsdon, Wallaceville). Stocking rates of perhaps 20-30% of those currently used may be possible, but under such rates (and in the absence of imported fertilisers) pastures would revert to native grasses and scrub. The presence of large numbers of daggy animals and no means of flystrike control would mean that 20-30% (Dr A. Heath, MAF, Wallaceville, estimates 20%) of lambs would die of flystrike during the summer months. (Estimates from Dr M. Alley, Massey University, NZVA Subcommittee on Nuclear and Natural Disasters.)

Selenium, cobalt and copper are important trace elements for animal health, and more than half of New Zealand's pastures are deficient in one of these elements. In the absence of imported cobalt and selenium, and without a renewed local capacity to recommence copper production, certain diseases and disorders could be expected to reappear. These include white muscle disease, bush sickness, diarrhoea and steely wool, (Dr M. Alley, Massey University, NZVA Subcommittee on Nuclear and Natural Disasters). Infertility in ewes is also a potential problem; selenium defficiency has been known to lead to lambing percentages as low as 25%. These problems would appear after about 5 years of not adding trace elements (Dr S.S.S. Rajan). It would be necessary to retire land deficient in these elements (2.8m hectares of New Zealand farmland was deficient in cobalt and 0.6m hectares deficient in selenium when farm land was tested for deficiencies in 1960).

It is questionable whether animal vaccine production would continue as the growth media rely on the importation of essential amino acids and vitamins unavailable in sufficient quantities in New Zealand. Certainly in the case of an EMP, New Zealand's vaccine factories would become inoperative. Even without an EMP, it is possible that our facilities would be converted to human vaccine production (this may take up to a year according to Arthur Webster Limited). Without animal vaccines, between 10 and 20% of mainly young livestock might die from diseases such as pulpy kidney, tetanus and blackleg (Dr M. Alley, Massey University, NZVA Subcommittee on Nuclear and Natural Disasters).

Listed below are the main raw materials used in the manufacture of our sheep and cattle vaccines:

Media substrates	NZ (Lactose/Casein poweders)
Enzymes	Japan, Europe
Sodium hydroxide	UK, USA
Diatomaceous earth	USA
Peptone powder	UK
Amino acids	Japan, Germany
Vitamins, minerals	Europe
Dextrose	Australia, Europe
Agar	NZ
Formalin	NZ
Filters	USA, Germany, UK
Adjuvant mineral oil	Germany
Preservatives	Germany, USA
Sodium selenate	Japan, Germany
Levamisole	Australia, China

Although many of these materials are used in only small quantities, they are all essential for vaccine production. We would normally carry several months' stock and with our stocks of intermediates would be able to continue vaccine supply for, say, 6 months, but after that would have to cease production without supplies of these materials. The lead time for having vaccines tested and ready for sale, assuming that we have to start from scratch with the raw materials, is in excess of 9 months (G. Conway, Manufacturing Manager, Coopers Animal Health NZ).

New diseases could well find their way into New Zealand if we were faced with accepting migrants who perhaps would be bringing infected food and animals with them. Potential problems include foot and mouth, rinderpest, swine fever, anthrax and rabies. There would be little likelihood of controlling these diseases in post-nuclear war conditions.

Pig and poultry industries would be badly affected in the long term. The poultry industry in New Zealand depends on bulk supplies of carefully formulated and often medicated feedstuff, and alternatives would need to be developed. Outbreaks of disease would be highly likely. The pig industry would be similarly affected, although whey feeding could once again become important in surviving dairying areas (if milking continued).

Fuel

Shortages of fuel (diesel and petrol) would affect the majority of farm machinery and all transport services (e.g. tanker milk collection). They would also curtail the activities of New Zealand's domestic fishing fleet. Fuel stocks held within the fishing industry itself (vessels, tanks and on-shore bunkering) would last for 3-4 months, assuming there was a cutback in the rate of fishing because storage facilities (freezing etc) could not be maintained. The absence of fuel would be most severe for horticulture and cereal cropping and would require more labour-intensive farming. (See Background Paper 6 for more detail on fuel shortages.)

Wine industry

The structure of the present wine industry would collapse because of its

dependence on imported machinery, chemicals (fungicides and insecticides), fuels, and an extensive distribution system. Although glass bottles are made locally, imported cork would be unavailable. Glass could be recycled if fluxes (presently 100% imported with stock piles of 1-4 months supply) could be replaced with local substitutes. Feldspar (with a low iron content) would need to be mined or quarried and thousands of tonnes of soda ash and sodium sulphate produced. This would prove very difficult in post-nuclear war New Zealand and require the continuation of major industrial plants, e.g. Kinleith and NZ Steel.

POSSIBLE OR LIKELY POST-WAR ADJUSTMENTS

Introductory comment

The nature of post-nuclear war adjustments in the food production sector would differ greatly depending on whether or not there was an EMP. In the absence of an EMP, adjustments are likely to be oriented toward maintaining "business as usual" as far as possible. Although the climatic changes would decrease yields, New Zealand's production is currently far in excess of local needs (we export the larger proportion of what we produce), so the nation should still be able to produce sufficient for its population. We probably do not know how many refugees we could absorb before this would no longer be true.

If an EMP were to occur, and assuming that it proved impossible to re-establish the national electricity grid, the following probable consequences are highly relevant to food production:

* Partial or complete breakdown of Motunui synthetic petrol plant (leading to severe fuel shortages) and of the Marsden oil refinery.
* Breakdown of telecommunications making nationwide planning improbable.
* Complete disintegration of the current food distribution system.
* Breakdown of the financial system.
* New social structure oriented around local communities.

These changes would lead to far more radical alterations to the food production scene in New Zealand than if no EMP occurred. The possible adjustments within each scenario will now be explored.

"Business as usual" as far as possible

A reorganisation of the entire farming sector would be required, from producing for export markets to production for the local market. In the case of the major export products such as meat, wool and dairy products, this would involve a drastic cut in production. For wheat and some other grain crops, an increase in production would be required for self-sufficiency. A decline in the total land area farmed would result from retiring lower quality land too dependent on chemical inputs.

Seeds

Growers in New Zealand have the expertise to produce vegetable seed. Crops grown from imported hybrid seed would be limited in their usefulness because the seed they produced would be highly unpredictable in quality. Thus it would be necessary to track down all open and self-pollinated cultivars (including cultivars discarded in the past). Increases in the most promising cultivars would have to be achieved after a nuclear war and this would require time and resources. Maintenance of seed and germ-plasm banks would be advisable as part of pre-war planning.

The potential for production of vegetables from home gardens is enormous (and would become vital in the event of an EMP. Home gardeners can be encouraged to save and use seed from their own vegetables (see Background Paper 13, "Impacts on New Zealand's Urban Systems.")

New Zealand would be able to produce sufficient wheat, barley and oat seed to meet local needs. If continued trade with Australia were possible, high quality wheat (which we currently import from Australia) would be an important part of that trade. This would depend on Australia still producing a surplus for export.

Presumably New Zealand could continue producing those seeds in which we are currently self-sufficient (peas, grey pumpkin, onions, sunflower seed, grass, animal crops, kumara and potatoes).

Horticultural production

Communities can survive on vegetables alone, without fruit, meats or even cereals. If the decline in pasture production and the recurrence of animal health problems were to make livestock farming much more difficult, then vegetables would become an important dietary component (although they may be of lower nutritional value due to problems with irrigation, weeds, pests and climatic variation caused by the nuclear war).

If national or regional planning were possible, then it would be sensible to orient it towards identifying staple foods to continue planting (e.g. potatoes), determining the most suitable crops for changed climatic conditions, and establishing the most appropriate locations for production (to fit with available distribution systems). It would be hoped that growers would be willing to accept the guidelines or quotas given by the bodies responsible for such planning.

One possibility would be the establishment of a national Food Production Council to assess food requirements (taking into consideration the needs of a balanced diet) and setting targets for the various production sectors to meet these demands as was done in Britain during World War II. Production Committees could be set up on a provincial basis to meet targets for seed supply, vegetable production, fertiliser requirements, etc. These committees could also have an advisory function. Home gardeners and small family holdings could be encouraged.

Pulse vegetables (legumes) not traditionally grown in New Zealand could be cultivated, and these would provide valuable protein as an alternative to meat. Lentils can be grown successfully in New Zealand, with yields of up to 2 tonnes per hectare having been recorded in small-scale farm trials (Logan, 1983). The Crop Research Division, DSIR, has been evaluating lentils since 1972 and suitable

cultivars have been selected. The lentil legume is cold-tolerant and well-suited to dryland farming, both characteristics of potential advantage in a post-nuclear war New Zealand. The chick-pea is another pulse which trials have shown could grow well here (Logan, 1983).

It is probable that much greater use would be made of glasshouses and plastic houses for horticultural production in the event of falling temperatures (assuming sheet glass manufacture and plastic production and supply continued).

Livestock numbers

Not only would New Zealand no longer be producing meat for export, but it is also quite possible that domestic demand for meat would decline because of animal health concerns, transport difficulties, and poverty. (Some people may buy only cheaper foods such as potatoes and other vegetables, or may rely on backyard chickens for protein.) It has been estimated (N. Wilson) that if the consumption of meat from sheep, cattle, pigs and commercial poultry stabilised at half the current national level, the number of animals on farms needed to meet this level of consumption would be as follows:

5 million sheep
0.7 million beef cattle
0.2 million pigs
1.6 million poultry birds

Fertilisers

If some form of centralised planning were operating effectively, then rationing of all imported agricultural chemicals may occur, to ensure that they were allocated to essential food production systems. Despite this, local substitutes would eventually have to be found.

At present, only one-third of the output of the ammonia-urea plant is consumed locally, and once all trade had ceased, total production would then be available for use in New Zealand (provided the plant was able to continue functioning).

Since there would be little export of mutton, much of this could be turned into blood and bone which would be valuable for many horticultural crops (provided there was energy available for production).

Moves to make use of Chatham Rise phosphorite as a source of phosphorus, or to extract potassic salts from seawater as a source of potassium would be very difficult in the absence of any overseas expertise or technology (see section entitled "Pre-war planning options"). Low-technology options are likely to be more attractive. These could include greater use of human and animal manure. Also of potential is the increased use of biological systems, including Rhizobium bacteria for nitrogen fixation and mycorrhizal fungi to assist uptake of phosphorus from the soil (see also section on pre-war planning options).

The point should also be made that in the absence of any need to grow surplus food for export, New Zealand's food production system could tolerate substantial decreases in yield (due to lack of fertilisers, pesticides etc.) before we were unable to produce enough to feed our own population. An influx of large numbers of refugees would, however, change the equation substantially. As would the desire to

have exportable products in the event of future trading being possible.

Pesticides

Pesticide shortages (inevitable in the long term, even with rationing of existing stocks) would affect the quality of production, especially in horticulture. At present, quality is paramount in fruit and vegetables grown for export, but no doubt in a post-nuclear war world people would have different standards in this regard. Quantity of production would also decline in some cases, e.g. cereal yields would be reduced substantially by the loss of herbicides. Best guesses for some crop losses in New Zealand in the absense of pesticides are tomatoes (30% reduction), sweetcorn (up to 30% reduction) brassicas (20%), potatoes - substantial losses (30%) due to disease transmitted by aphids. For horticulture, apples (20-70%), berry and stonefruit (20-30%), citrus (30%), kiwifruit (5%), grapes (up to 30% reduction if the effect of birds is included). (John Charles, DSIR, Mt Albert Research Centre.)

New Zealand currently has some local capacity to manufacture herbicides and insecticides. It may be possible to establish a simplified agro-chemical industry on this base, perhaps concentrating on two or three basic, general purpose insecticides. Ivon Watkins-Dow Ltd estimate that given the current reliance on overseas imports and electricity, there would be a 90% drop in production levels.

Crop plants might be grown as a source of the natural insecticide, pyrethrum. Other strategies include:

* Planting increased areas (e.g. of maize and other cereals) to compensate for reduced yields.

* Tolerating occasional severe pest outbreaks (as in pre-1950 New Zealand conditions, when, for example, grass grub outbreaks were common on the Canterbury Plains).

* Adopting management systems which minimise the effect of pests on production (for example, avoiding large areas planted in a single crop).

* Accepting greatly reduced quality *and* quantity (given absence of ability to export in the foreseeable future).

* Much greater use of biological control systems (based on viruses, bacteria, protozoa, fungi, nematodes which attack the pest).
  N.B. This is in some forms a high-technology option, for which development in a post-nuclear war New Zealand would be difficult. The control agents often need to be produced industrially.

* The rapid multiplication and release of arable and vegetable cultivars which require lower inputs of pesticides and other chemicals. (Much of this material is already in the country but it could take several seasons to increase seeds to supply local needs.)

Fuel

Shortages of liquid fuels will have their most dramatic impact on food distribution (see Part C), but production would also be affected. Farm machinery such as tractors could be converted to use indigenous fuels. Methanol, for example, could be derived from natural gas while that resource lasts, and in the longer term could be manufactured from biological matter. The technology is available in New Zealand for converting wood to ethanol, and although this is uneconomic at present, it would be a sensible strategy in a post-war New Zealand where overseas markets no longer existed for our wood.

Biogas (methane) is another potential fuel for farm machinery, and it can be easily manufactured on a small scale from a range of organic wastes.

Linseed oil and brassica oil are also potential diesel substitutes. Their use as such would be possible only if the land for growing linseed and brassicas could be spared from food production, and if New Zealand could become competent in the technology of oil extraction. Tallow mixes can be used to extend diesel stocks and "ethanol methanol, propanol and butanol, can be made from whey" (P. Wood, Dairy Engineering, MAF).

Another strategy would be to become much less reliant on machinery in food production. Farming could become much more labour-intensive. Simpler technology based on horse-power may again be adopted, provided that we still had appropriate skills in the population, the right sort of horses and could develop the necessary equipment. During the 1939-1945 war, the "back to the horse movement faced severe limitations: it took four years to rear a working horse" (Taylor, N., 1986, *The Home Front*, Vol 1 : 325).

Animal health and production

It is possible that the severe animal health problems faced in the absence of imported anti-parasite chemicals, trace elements and possibly vaccines would make intensive livestock production impractical. New Zealanders may become more vegetarian, perhaps relying on semi-wild herds of hardy animals such as goats and deer for the occasional meat meal. If sheep and cattle farming were to continue, the numbers would drop to a level at which natural soil fertility could support the stock. Careful management would be needed.

Old-fashioned methods of treating parasites and pests may re-emerge. These include the use of chemicals such as arsenicals, nicotine*, copper sulphate and carbon tetrachloride. These tend to have low efficacy and toxic side effects.

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* New Zealand presently has 725 ha producing about 1740 tonnes of tobacco annually which represents about 35% of New Zealand's consumption. Motueka is frost-prone, and temperature drops of 1-3^{o}C with increased frost-occurrence would decimate the crop. (Tobacco growers federation.)

If horses were to be in widespread use once more as a machine substitute, then treatment of their ailments would have to be attempted with herbal remedies and skills relearned from the past.

Backyard pig and poultry production, in which the animals were fed primarily on waste, could re-emerge as important sources of animal protein.

Fish farming (using existing dams and waterways) would have considerable potential.

Fishing

Because of its currently high dependence on imports, the nature of the fishing industry would change dramatically. Methods used in fishing and in support industries would revert to earlier technology, and considerable training and re-education would be needed. State control of the industry might be necessary to ensure that scarce equipment was husbanded and that fish were harvested and distributed for the common good.

Control of shoreline fishing for shellfish, crayfish and finfish would be very hard to police. Many New Zealanders would harvest this resource and depletion is highly likely.

There would be a return to passive methods of fishing, including lines and hooks, gill netting and fish traps. People would have to swim or sail to reach fishing grounds. Fish stocks would become more abundant in the medium-to-long term (because of the cutback in harvesting and the reversion to simpler methods).

Given no EMP, trade with Australia could entail an exchange of their fuel, lubricating oil and mechanical resources for our fish.

A radically different society

The preceding section outlined some adjustments which might be made in a New Zealand where food continued to be produced by a minority on behalf of the whole population. Such a system would require the continuation of food distribution networks, and would be consistent with a society in which nationwide communication and government had remained possible. If transport systems were to fail and the continuation of a central government prove impossible (this would be more likely if an EMP occurred,) then far more radical changes to New Zealand's food production system would result.

We might return to an 1880s' type of livestyle. The absence of transport fuel to distribute food around the country would lead to social transformation into rural, self-reliant and independent communities. These communities would need to be self-sufficient in food, probably relying on vegetables and the occasional chicken or pig from backyard production. Simple energy technologies, such as windmills, small hydro generators and biogas production, would emerge. Human and animal wastes could supply fertiliser, and only simple methods of pest management and control would be possible.

Despite the likely collapse of the wine industry, the demand for alcohol would be likely to increase because of the psychological trauma following a nuclear war. Local community alcohol production may emerge. Grapes could be grown throughout New Zealand (apart from Southland), although a change of varieties would be needed in the absence of agricultural chemicals to control insect pests and fungal diseases. Cooler climatic conditions would reduce the quality of the wine which could be made. The land area required for wine production for a family unit, of

four persons per family with a mean annual consumption of 30 litres of wine per head, would be 500 m^2 (.05ha). (Figures provided by R. Smart, MAF, Ruakura.)

The transition from current New Zealand society to the decentralised, largely anarchic one depicted here could be very unpleasant. The farming community might be particularly affected. Inhumane slaughter and theft of livestock would be commonplace. Farmers might band together and and employ "armies" of vigilantes to protect their animals and land from city migrants. Many city dwellers, particularly the unemployed, would migrate to the country, some seeking to live with farming relatives in order to obtain food and land. While some communities and small family groups might adopt the new lifestyle quite readily, its widespread implementation would take a long time.

Pre-war planning options

Agricultural chemicals

The two possible approaches here are (1) to aim for a greater degree of industrial self-sufficiency in chemicals production, and/or (2) to research and promote methods of food production which do not rely on chemicals to the same degree.

As an example of the first approach, there are adequate raw materials for fertiliser production in and around New Zealand. Some 4 million tonnes of marine phosphorite sits on the Chatham Rise, off the east coast of New Zealand. However, the technology of dredging the phosphate from the sea bed is expensive, and currently we depend on German expertise. We could choose to build up local expertise and technology. Similarly we could invest more research money into adaptation of overseas technology for the fractional crystallisation of potassium chloride from seawater. New Zealand has a local resource (4 million tonnes) of sulphur at Lake Rotokawa (near Taupo). Fletcher Challenge is already exploring the possibilities of commercial mining and purification of this sulphur. They estimate that 100,000 tonnes could be extracted annually using present technology, but it would be expensive. The equipment used is heavy industrial, unlikely to be affected by an EMP.

For pesticides a similar approach would be the accumulation of large chemical reserves to last until we could manufacture our own (using imported basic materials also stockpiled prior to war).

The alternative approach would be to encourage more detailed research on organic farming and other systems of agriculture suitable for post-war conditions. We could begin now to educate all farmers (and home gardeners too) on "biological husbandry", an approach which aims to maintain production with minimal inputs of fertilizers, pesticides etc. To achieve this, management could be directed at enhancing the natural biological activity of an area, growing only those plants which are well within their climatic areas, and maintaining a healthy soil. It would rely on using such techniques as crop rotation, using plant and animal wastes for manure, and biological pest control. Within New Zealand's horticultural industry, there are some 67 growers, with a total of 125 hectares, in "organic" crop production (HMRU, 1986).

Biological pest control is an important alternative to chemical pesticides. A major aspect of this approach is the commercial production of pathogens (bacteria, viruses etc.) of insect pests. This is an industrial approach to the problem, in

which chemical insecticide production is replaced by bioinsecticide production. As such, its feasibility is questionable in a post-nuclear war New Zealand. Although the current MAF and DSIR research into the use of pathogenic viruses, bacteria, protozoa, fungi and nematodes (Hunt, et al., 1983) is generating potentially useful information about organisms for biological pest control, a greater research emphasis on low-technology options would better prepare us for conditions after a war.

Similarly, current MAF and DSIR research into the use of Rhizobial bacteria for enhancing nitrogen fixation in legumes, and mycorrhizal fungi for improving soil phosphate uptake, is making a potential contribution to a chemical-free future.

Seed stocks and plant breeding

Seed stocks should be established. At least one year's reserve of seed would need to be held by the horticultural seed trade; mother seed of open-pollinated seed should be held, and if possible parent material of hybrid cultivars obtained. Home gardeners should be taught how to save their seed. Seed could also be stored for crops which we might need after a nuclear war, such as sugarbeet (for producing sugar and/or as a source of methanol fuel) and lentils.

Because there may be climatic changes to which the current seeds are not suited (and they have a narrow gene base in many cases) it is important to establish gene banks now, in which all genetic material which might be needed for plant breeding programmes is kept. Storage in these base collection gene banks should be around -20°C, and hence they would need to be supplied with backup power generators in case of an EMP.

All plant breeding lines should be maintained, whether or not they are currently commercially viable. Old cultivars should be kept going.

We could begin now to import and/or develop varieties of all our crops which would be resistant to diseases and pests, as well as varieties which could grow in low-fertility soils.

Pre-planning the role of government

Many of the adjustments envisaged in the preceding sections entail a much more directive role for government, e.g. in taking control of the fishing industry, in deciding what crops will be planted and where. Discussions now between private industry and the government could be aimed at establishing in advance a commitment by all to this type of action, and clarifying the specific changes that would need to occur in each industry.

PART B: FOOD PROCESSING

BACKGROUND INFORMATION

The manufacturing sector in New Zealand is dominated by industries which process New Zealand's primary products. Production from the food processing sector accounts for 46% of New Zealand's export receipts (Patterson and Earle, 1985). Meat and dairy processing dominate this sector.

Energy use

The three major energy users are meat export works, dairy factories and fruit and vegetable processors. Oil, coal and natural gas are the most important sources for direct energy use. Electricity meets only 12% of the industry's direct energy requirements. Packaging (cartons, shrink wrapping, boxes etc) is the major indirect energy requirement, and represents 15% of the total energy requirements of the sector (Patterson and Earle, 1985).

Meat

Meat processing consists primarily of division of the animal carcass following slaughter. Only 1% of meat is sold extensively processed. Tallow is a major by-product of the meat industry, annual production being around 130,000 tonnes. Of this 115,643 tonnes is exported for use as animal feed or for producing glycerol and fatty acids. Possibly a source of diesel fuel in a post-nuclear war New Zealand.

Dairy processing

This section outlines the present production, consumption, stock levels and storage life of our main dairy products. At present, the majority of New Zealand's dairy products are exported, and all the major export markets are in the Northern Hemisphere.

Cheese production is about 127,800 tonnes p.a. with local consumption about 27,500 tonnes p.a. (i.e. 22% of production). The storage life of cheese is about two years in cool storage. Stocks of cheese in New Zealand vary markedly on a seasonal basis but typical minimum stocks are around 60,000 tonnes. This is equivalent to about 2.2 years of local consumption - near the storage life of cheese. Little cheese would probably need to be made for some considerable time.

Skim milk powder production is about 200,000 tonnes p.a. with local consumption about 11,000 tonnes (i.e. 6% of production). Storage life is at least 5 years in unopened 25kg bags. Skim milk powder is stored in ordinary rodent-proof warehouses. Typical minimum stock levels of skim milk powder (July/August) would be about 20,000 tonnes (i.e. 1.8 years of local consumption).

Whole milk powder production is about 160,000 tonnes p.a. with local consumption about 9,000 tonnes (i.e. 6% of production). Storage life is about three years in unopened bags but longer in cans. Whole milk powder is stored in ordinary warehouses. Typical minimum stock levels of whole milk powder would be 8,000 to

10,000 tonnes with an additional 5,000 to 8,000 tonnes of buttermilk powder. When stocks of these two products are combined, they are equivalent to between 1.4 and 2.0 years of current New Zealand consumption.

Butter production is about 300,000 tonnes p.a. with local consumption about 39,500 tonnes (i.e. 13% of production). Stored in cold storage (around -14°C), typical minimum stock levels of butter are around 100,000 tonnes. This is 2.5 years of supply at current consumption rates. Butter lasts about two years in cold storage.

Casein and caseinate production is about 70,000 tonnes p.a. with almost all of this exported. The storage life of casein is virtually indefinite and the various caseinates have a storage life of about three years in unopened bags. Casein can be used as an adhesive and caseinates would generally find use as sausage meat stabilisers.

Liquid milk consumption is about 490 million litres p.a. which includes liquid milk, cream and ice cream:wholemilk equivalent (NZ Dairy Board Annual Report). New Zealanders drink 106.5 litres per person per year (New Zealand Milk Board). In addition, the New Zealand population consumes as manufactured dairy products the equivalent of another 430 million litres of milk per year (with butter consumption limited to 20% of current production). When combined with the liquid milk consumption, this represents about 12% of New Zealand's current total milk production. If current consumption levels of butter are to be maintained, about 18% of our current milk production will be needed. This would leave a surplus of skim milk which could either be dried or fed to animals as in earlier times.

(Source of information: P. Wood, MAF, Hamilton.)

Fruit and vegetables

Most of our horticultural products are eaten fresh, and processing has grown only slowly. In 1986 production comprised:

	tonnes	(1985) exports
Canned and bottled vegetables	27,000	(6,336)
Frozen vegetables	45,000*	(33,093)
Fruit juices	73,000	(3.23 million litres)
Canned, bottled and dehydrated fruit	21,000	(7,665)
Frozen fruit	?	(8,196)
Jam	6,200	(689)

Figures in brackets are export quantities for 1985.
Source: NZ Department of Statistics and * Watties NZ Ltd.

Processing of cereals

Maize is grown for use mainly as animal feed. Small quantities are used to produce human foods, including cornflour and breakfast foods like cornflakes. Some

maize is used in the production of spirits.

About one-sixth of *oat* production is used by millers for producing oaten products for human consumption, especially rolled oats and oatmeal. The rest is used directly as stock feed and seed.

About 25% of the *barley* New Zealand grows is used for malting, in the beer industry, with small amounts also being used in the gin and whisky-making industries. The principal use of barley is in the stock feed industry.

Wheat is used predominantly for flour production; the main use for non-milling wheat is as an input to poultry feed.

There are 20 flour mills in New Zealand, situated from Auckland to Invercargill. These produce flours of differing characteristics to suit the needs of bakers. Wheat which will produce a "stronger" flour is suitable for the production of bread, crackers, fruit cake, puff pastry and other products. This comprises about 80% of the market, and the demand is spread around New Zealand. The remaining 20% of demand is for a "weaker" flour suitable for hard sweet biscuits, short pastry and cakes. This demand is mainly from biscuit manufacturers in Auckland, Wanganui and Dunedin (Logan, 1983).

THE DAIRY INDUSTRY - A CASE STUDY

The material for this section has been provided by Peter Wood of the Ministry of Agriculture and Fisheries, Hamilton.

Likely impacts of nuclear war

Immediate impacts

Presumably, some essential staff would not turn up for work, particularly in dairy factories near urban areas. If the banking system failed there would be no money to pay staff or dairy farmers. In that situation it is perhaps unlikely that dairy factories would continue operating at all.

Most dairy factories have in storage about seven days' supply of diesel (at peak-season consumption rates). Once this was depleted it would be impossible to collect milk from farms. For this reason, and because of the decrease in demand, it would be sensible to reduce or cease milk collection in some areas.

Dairy product stores could well become depleted by looters, particularly in factories near urban areas. A priority would be to secure these stores, and also the large quantities of dairy products which at any one time are on their way to, or are at, ports.

To allay public anxieties, monitoring of town milk supplies for radioactivity would be necessary. Without this, consumer demand could drop dramatically because of concern about contamination by radioactive fallout. (Radioactivity is concentrated as it moves up the food chain through grass to cows and milk.)

The occurrence of an EMP would have dramatic effects. The automated electronic equipment which most factories now use would be destroyed. In a few days manual

control could be re-established; however, the loss of mains power would paralyse dairy factory operations. If electricity supplies were to fail for more than a day or so it would be essential to clear milk and semi-processed products from the dairy factories.

The loss of electricity could also disrupt dairy product cool stores and freezers. They would have to be kept closed, and in this case would maintain cool temperatures for several weeks.

Anticipated problems in the first 6 months

* Difficulty in maintaining supplies of diesel fuel for tankers could possibly be overcome by adapting them to CNG, possibly using CNG bottles salvaged from domestic vehicles. Further research is required to overcome fuel shortages and investigate alternatives.

* Spare parts for machinery could be a problem. In the short term local production and canibalising surplus machinery from dairy factories and elsewhere would help overcome this problem.

* Some staff would have severe psychological trauma which would prevent them from working effectively.

* Economic problems would arise for dairy farmers who were no longer able to supply a dairy company because their farm was either too far from an operating dairy factory or their milk was just not needed.

* Economic problems would arise for the staff of the closed dairy factories. This could probably be overcome by relocating them to operational dairy factories which would need extra staff.

* If the throughput of dairy factories were reduced there would be 'scale-down' problems as they are run below their design capacity. This would be less of a problem on some sites than on others, e.g. Te Rapa would run only one of its three evaporator/drier sets.

* The levels of dairy products in store in this country represent a number of years' supply at current domestic consumption rates. There would be some conflict between the need to keep the dairy factories operational and the need to use up some of the stored products.

* If the electricity supply could not be re-established, the existing dairy processing industry would not be viable, even in an extensively modified form. The dairy industry would have to revert to the form that it had about a hundred years or so ago. This means that it would consist of many small, labour-intensive factories producing one or two products, mainly for local consumption. There may be a return to on-farm production of butter, cheese and cream.

Anticipated longer-term problems and expected adaptations

The main long-term problems (assuming that power supplies are maintained, or can be re-established in the long term) would be:

* The supply area for existing dairy factories is too large if transport fuels were to become limited. This might not be too serious because markedly reduced production would be required and there would be the possibility of reopening some old dairy factories.

* The main dairy farming areas are not close to the main centres of population. Transport of manufactured products to urban areas could be a problem.

* Stocks of imported commodities would run out. This would include plastic milk powder bags and cheese wrappers. Recycling and local alternatives would need to be developed.

* Eventually, important machinery for which locally-made spares were not available would break down. These machines would have to be replaced with less sophisticated alternatives. This could mean a return to open-vat cheesemaking and rotary-churn buttermaking. Very little of this equipment remains but it could be fabricated. The technology of open-vat cheesemaking is fast being lost. Only older cheesemakers and some of the new farmhouse cheesemakers have an adequate understanding of this technology.

* The quality of the raw milk supply would deteriorate as dairy farm refrigeration systems broke down irrevocably. The loss of refrigerant gases could be the limiting factor. The loss of imported veterinary products could also affect milk quality (not always adversely; for example, there would no longer be residual antibiotics in cheese milk).

* Many inputs to the dairy industry are made locally and problems would arise if their production or transport was disrupted. Boilers are fuelled by coal, natural gas and woodwastes. Rennet for cheese making is manufactured from salt and frozen calf vells at Eltham. In the absence of export cheese markets, rennet use would drop to, say, 25% of current needs. Continued production should not be a problem unless power supplies were to fail for long periods. Salt for butter and cheese making is refined locally, as are the cleaning and sanitizing chemicals used by the industry. Nitric acid is imported but it should be feasible to make it locally. Microbial cheese starters are provided by the Dairy Research Institute; local subculturing is a possibility if this supply failed.

  In the longer term, an absence of antibiotics, vaccines and veterinary services would adversely affect herd health, and some consumers might avoid dairy products, especially if tuberculosis became more common in cows.

Pre-war planning options

To enable the dairy processing industry to better survive the impacts of a nuclear war:

* There would have to be plans for an altered production pattern. This plan would need to take into account the following factors:

  - Reduced production to supply only the New Zealand population. Some

large butter and milk powder factories would not be needed. Casein factories would probably not be needed at all.

- Some dairy factories might need to be adapted to produce other products.

- Some factories have access to local energy supplies. Examples include:

  Reporoa and Hikurangi on wood waste;
  Waitoa, Waharoa and Te Rapa on coal with electrical co-generation;
  Tirau partially on biogas;
  Kerepehi, Paerata, Paeroa, Te Awamutu and others on coal;
  Morrinsville and many others on natural gas.

- There would have to be a reasonable geographic distribution of dairy factories due to difficulties in transporting the finished dairy products to centres of population.

- It would probably be desirable to keep the four ethanol plants operating. Ethanol is a potential transport fuel.

* There should be plans for the orderly transfer of ownership of at least part of the stocks of dairy products held by dairy companies but owned by the New Zealand Dairy Board.

* There should be education programmes for key dairy factory staff so that in the event of a nuclear war they would know what to expect and how to respond. It would be useful to develop a manual for dairy factories containing the information that they would need.

* There should be preparation for the long-term return to a lower level of dairy processing technology. This would include plans for simpler separators, open cheese vats, 'conventional' butter churns and information on the older dairy technologies, e.g. rinded cheese manufacture. If the electricity supply grid failed and could not be restored, this transition to the older dairy processing technology would have to be swift.

* There might need to be plans to replace the supply of fresh town milk with reconstituted milk if it was considered that the risk of radioactive iodine from Australian targets was a problem. This would only need to be done for about 32 days (4 x half-life of radioactive iodine). Alternatively, an extensive programme of radioactivity-monitoring of town milk would need to be started to reduce public anxiety. Supplies of radiation meters would be needed.

Alternative products

It is possible to manufacture a wide range of chemicals from whey, currently a waste product. In a post-nuclear war world, the dairy industry might be the source of a wide range of our chemical supplies. These could include some antibiotics and glues, the preservative niacin, lactic and citric acids, methanol, ethanol, propanol, butanol and acetone. In addition, acrylonitrile can be made - giving the feedstock for a plastics industry. Of these products only ethanol is currently

economic. The microbial cultures for these fermentations all store easily but are not all held in New Zealand. They could be easily added to our culture collections.

The technology for these products is to a varying extent known, though some of it is old and not well documented. All cheese factories and casein factories have large-scale, sterile fermentation facilities for the production of starter cultures. These should be ideally suited for the production, by fermentation, of other materials.

As a contingency preparation a small group of specialists could assemble the technology and identify areas where further work is needed. If further work is needed, perhaps on a pilot-scale level, this could be done at the universities as final-year student projects. Either Auckland or Canterbury Chemical Engineering departments or the Massey Biotechnology department would be suitable.

Other food processing sectors

There is very little detailed information on the impacts of nuclear war-induced isolation on other sectors of the food processing industry. In most cases the degree of disruption would be much greater if electricity supplies were cut by an EMP. Many of the comments made for the dairy industry - e.g. effect on staff, transport of raw materials, loss of old technologies - are relevant for other sectors.

Processing as preservation

If electricity is no longer available for fridges and freezers (both domestic and industrial), then other forms of processing for preservation might be needed. Canning would become more important, provided that canning factories were able to develop their own independent power supplies. Drying and salting of foods such as fish would also become more important again.

Wood and coal fires might replace electricity for cooking where fuel and hearths were available.

The canning industry

Food canners would be severely affected by an EMP disrupting electricity, but the degree of impact would depend on the duration of power loss. (Some factories have backup generators which require diesel supplies.) Most factories are practised at dealing with short-term power cuts and can recover quite quickly once electricity is restored.

The major electrical equipment in the canning industry comprises water pumps and boilers, which are not reliant on micro-electronic components. (Hence they would not be deactivated by an EMP.)

A key import for the industry is tin-plate which comes from Japan in 6-monthly shipments. Stocks are generally down in July. Australia is another potential supplier, and if there were no EMP this trade might be possible. It would depend, however, on whether Australia was willing to supply us, and whether their own tin-

plate industry was still operational.

Lubricants for machinery are also imported. The industry usually carries several months' supply in stock. In the longer term it would be dependent on the development of an indigenous substitute.

Mills and bakeries

Much of the mills' equipment is imported. Housing and frameworks come from Germany, Britain, Switzerland, Japan and the USA. This plant does, however, have a very long life (60-80 years) and New Zealand has the ability to make spare parts except for bearings. (NZ Cereal Foods.)

Bakeries would be more severely affected in the short term by an EMP. Around 50% of the baking requirements for major metropolitan areas relies on computerised ovens, and a return to manual operation would be very difficult. Most bakeries are heated by gas or diesel, but electricity is essential for mixers, slicers, and provers (which enable bread to rise quickly). (Wellington Bakeries.)

Oven equipment is assembled in New Zealand from locally produced and overseas components imported from Japan, Germany and the UK. Spare parts would be in short supply (about 15 motors and instruments are currently in stock), but the ovens last 10-15 years (Baker Perkins, Auckland). Other key imports are oil, lubricants and transport fuels for bread delivery. Like all other food sectors, the long-term survival of this industry would be dependent on the development of local substitutes for these inputs.

The meat industry

Meat works would be severely affected by the occurrence of an EMP. The meat-processing chain is extensively controlled by microprocessors. Electricity failure and water supply problems would also stop the operation of the chain. After 4 days without power restoration, meat would be rotting and would need to be disposed of. In the absence of export markets for our meat, many meatworks might close down, creating severe problems for the dislocated workers and potential health problems from unhygenic processing.

Prewar preparation

In all sections of the food processing industry, the development of alternative backup power sources would be a logical pre-war planning option.

Research would be valuable into processes by which surplus meat and dairy products, etc, might be converted into import substitutes, e.g. tallow into diesel. (The Liquid Fuels Trust Board Report, No. LF2021 and 2032.)

PART C: FOOD DISTRIBUTION

BACKGROUND INFORMATION

Almost all of New Zealanders get their food from supermarkets or other retail outlets supplied by both local and international producers. The food on the supermarket shelves has travelled varying distances from a wide range of dispersed points of production, and has passed through storage, processing and marketing sites on its way. Only 5% of New Zealand's population of over 3.291 million (1985 figures) are employed directly in the farming sector (and this 164,000 includes part-time, casual employees and unpaid members of families assisting with farm work). The rest depend totally on a complex distribution network which gets the food from the farm paddocks to our tables.

The following table indicates how the fruit and vegetable markets in Dunedin, Wellington and Auckland are supplied. In the case of Dunedin and Wellington there is usually about one week's supply of fruit and vegetables in the city. In Auckland there can be as much as 3 days' supply (Mondays and Thursdays). Auckland has coolstorage facilities.

City	Fruit/vegetable	Source (varies through the year)	Mode of transport
Christchurch	Vegetables	60% local to city	South Island
		Most sources in South Island	Road 80% Rail 20%
	Fruit	10% local (mainly apples and pears)	North Island Rail 100%
	Stone Fruit	Hawkes Bay, Nelson	
	Citrus and subtropical	Bay of Plenty, Northland, Auckland	
	Tropical	Australia	Almost all by air
	Bananas, Oranges	Australia	by sea
Dunedin	Vegetables	85% Tairei Plains (20 km away)	Road 90% Rail 10%
	Carrots	Invercargill, Christchurch	
	Onions	Christchurch, Nelson	
	Potatoes	South Otago, Canterbury	
	Stone fruit	Early Season: Hawkes Bay, Blenheim, Nelson Main: Central Otago	
	Citrus fruit	Tauranga, Kerikeri	
	Bananas, grapes, pineapples, oranges	Overseas	

Wellington	Vegetables	Lower Manawatu and Horowhenua (closest source is Otaki, 40 km away)	Road 66% Rail 33%
	Potatoes	Wairarapa and Horowhenua	
	Onions	Pukekohe	
	Fruit	Winter: Bay of Plenty, Poverty Bay, Kerikeri, Nelson Summer: Hawkes Bay	
	Bananas, oranges etc	Overseas	
Auckland (75% of all fruit and veges from within the Auckland Province)	Vegetables	Major supplies: From Franklin district (Pukekohe, etc) and the perimeter of Auckland. Seasonal shortages: Otaki, Palmerston North, Ohakune	Road 80% Ship, air, rail 20%
	Taro (important to Islander population)	Pacific Islands (Western Samoa, Tonga)	
	Stone fruit	Hawkes Bay, Blenheim, Central Otago	
	Citrus and subtropical fruit	Kerikeri, Bay of Plenty, Gisborne	
	Bananas, oranges etc	Imported	

Likely impacts of nuclear war

New Zealand's road and rail transport systems depend on imported fuels and imported spare parts. These would not run out immediately, and all other things being equal, food distribution systems should be able to continue operating. Other factors, however, would be likely to disrupt the system in the short term. People's immediate response to the news of war might well be to head for the supermarket. Panic buying, and in some cases looting, would occur. Retailers might attempt to refill the emptying shelves, thus placing increased pressure on the food transporters.

Effects would be even more dramatic in the case of an EMP. The immediate shutdown of all air and electrified rail transport would boost the demand for road transport, which itself would be disrupted by the loss of all traffic lights and street lighting. But even these physical disruptions would be small compared to the social disruption likely to occur if all communications and electricity were suddenly lost. Many people would respond by staying with their families rather than going to work. Supermarkets might not open, food transport trucks might not run. Within a few days those who chose initially to go to work might stop doing so, especially if the banking system failed and there was no prospect of being paid.

If the food transport system was able to survive the immediate impacts, shortage of fuel would restrict their activities in the medium term. In the longer term,

shortage of spare parts, and eventually vehicles, would be a problem.

Changes in employment patterns and the financial system would impact upon food distribution via people's ability to pay for food. New Zealand might become a microcosm of today's world, where people are hungry not because the earth cannot produce sufficient food for all, but because it is not distributed fairly and because people who need it can't afford to pay for it. In a post-nuclear war New Zealand, thousands of jobs would be lost from our exporting industries. How could the unemployed pay for food? It is hard to imagine the government continuing to offer unemployment benefits when its own tax-take was substantially cut back. The financial system might break down completely as farmers and their bankers realised there would be no export income in years to come.

In the longer term, the arrival of migrants, perhaps from Australia and/or the Northern Hemisphere, could add further stresses to our food distribution system.

Possible post-war adjustments

New Zealand's ability to continue distributing food to all the population would depend almost totally on one key variable: the ability of central government to control and direct the food distribution system. There would be an immediate need to ration fuel and to set priorities for the transport system as whole. This would entail defining priority routes to be serviced and priority goods (such as food) to be transported. A centralised planning operation would need to direct the regional movement of food to areas of need, and in an appropriate order, i.e. fresh food first, followed by that stored in temporary locations (coolstores and freezers). Canned and dried food could be held back for later distribution. In the event of an EMP, the distribution of food in coolstores and freezers would be more urgent. Householders would need to be advised to cook and eat food from fridges and deep freezes, while keeping canned and dried food for later.

If panic buying and looting was widespread, some form of martial law might be introduced.

In the longer term, centralised planning would extend to government direction of the types of food to be grown, and the places in which they were to be grown. Vegetables might become a more important part of our diet because vegetable-growing areas are closer to urban centres than are meat and dairy farms. Control of the food system would be but one aspect of a centrally-controlled economy based on direction and rationing. The alternative would be complete social breakdown.

If an EMP occurred, the maintenance of control by a central government would be much more difficult. A period of social chaos would be likely. This might be followed, in the longer term, by a highly decentralised economy based on a mix of small farms and factories. People would have moved away from the cities and out to join friends or relations in the country, close to where food is produced.

In either case, with or without central government control, the localisation of food supplies would be a logical development in a country short of transport fuels. People living in Dunedin would no longer have supplies of kiwifruit from the Bay of Plenty. There would be less variety in the average diet. However, we could all have a nutritionally adequate diet if in each geographical area the following were present:

* a cereal crop or crops produced
* meat and dairy sources available
* maximisation of fruit and vegetable production, emphasising:

    1) root crops such as potato and kumara (staple and high-energy vegetables);
    2) fruits with best keeping qualities, e.g. apples, kiwifruit

* simplified food processing.

This decentralisation of production would require massive reorganisation in areas which are at present devoted primarily to one type of farming.

The size of each "geographical area" would depend on the long-term capability of the transport sector. If we reverted completely to horse-drawn transport, each area would have to be smaller than if we were to develop a national industrial capacity to produce and distribute our own transport fuels (e.g. methanol from waste plant material).

For people living near the coast, much greater use might be made of marine food sources. Once fuel oil and diesel were depleted, fishing boats might use sail power.

Pre-war planning options

The following are feasible preparations which New Zealand might make:

* preparation of contingency plans for the distribution of foods
* stockpiling of dried and canned food in homes and institutions (lentils, chickpeas, mung beans and other dried beans are particularly suitable; they store well and are high in protein)
* stockpiling of diesel fuel and fuel oil for fishing boats, fuel and spare parts for road transport
* research into alternative transport systems (airships etc), and alternative fuels.

PART D: IDEAS FOR FURTHER RESEARCH AND PLANNING

Further Study

It is quite likely that a considerable amount of information and work has already been generated in the following areas. It needs to be collated and applied to conditions in a post-nuclear war New Zealand.

1. Responses from the questionnaire indicated that there is a reasonable amount known about the effect of falling temperature on crop and pasture production. However, the following areas merit further study:

   * the effect of increased UV radiation on plant and animal production
   * the magnitude and effect of any nuclear fallout New Zealand might receive on plant and animal health
   * the effect of drought on plant and animal production
   * the effect of changes in frost frequency and severity on plant and animal production.

   NB. This study should include impacts on pest and diseases, and on beneficial insects such as bees.

2. It would be useful to estimate the population-carrying capacity of New Zealand under conditions of minimal chemical inputs to food production. It would be important to explore the implications of differing assumptions about alternatives in use (e.g. manures in place of fertilisers, biological pest control).

3. A major area of uncertainty is the issue of if and when the national electricity grid would be re-established following an EMP effect. This is particularly important in the food processing sector, which could not continue in its present form without electricity. (Would it be feasible for food processers to set up their own power supplies?) The future of food distribution is also greatly affected by this issue, via the continued operation or otherwise of Marsden Point and Motunui as liquid fuel plants.

4. Information remains incomplete on the topic of critical import supplies (machinery, oils, chemicals etc) for the food processing industries. Having identified what these are, it would then be useful to assess whether or not they (or substitutes) could be manufactured in New Zealand in the long-term.

5. It would be instructive to prepare reasonably detailed plans for the relocation of people and food production in a post-nuclear war New Zealand, assuming that food production would need to be geographically much more localised. During planning, alternative sets of assumptions about the following should be considered:

   * quantity, type and distribution of transport fuel supplies
   * extent to which land is used for non-food crops (e.g. sources of

drugs, of transport fuels and of other chemicals)

* the number of refugees accepted into New Zealand

* dietary regimes (e.g. do we become completely vegetarian?)

* availability of trace element supplies.

6. A scenario for the food system should be developed on the starting assumption of a complete breakdown of the financial system. It needs to address such questions as:

* why would farmers continue to produce food?

* how could food distribution continue?

* how would people pay for food?

7. This is indeed an area in which "everything is connected to everything else". Existing models of the New Zealand economy should be run with the assumption of zero imports. Either existing or new industry input-output models, which trace the relationships between New Zealand's many industries, should be used to explore the ramifications of post-war changes.

8. A great deal of research has already been done in New Zealand on indigenous alternatives to materials which we currently import. There is a need to pull together the most recent research in the following areas:

* organic farming

* biological pest control

* production of transport fuels (biogas, methanol, ethanol, diesel) from plant material

* growing of crops for the production of drugs, fabrics etc.

Once a thorough literature search had been done, it would then be appropriate to apply that existing information to conditions in a post-war New Zealand and to identify areas where further research was needed.

Areas for action

Given the political will, action could be taken now in the following areas:

1. The establishment of seed banks and gene banks for all plant crops currently or potentially important in New Zealand.

2. The breeding of plant cultivars which are tolerant of low soil fertility, lower air temperatures, drought and other potential post-nuclear war conditions. The breeding of pest- and disease-resistant cultivars would also be useful.

3. Contingency planning for the distribution of stocks of fresh and frozen food in the short term. This sort of preparation is particularly important in the event of an EMP (which would affect freezers and cool stores) and/or a breakdown of the financial system.

4. Initiate discussions between government and the private sector, e.g. fishing industry, road transport sector, on the issue of relative responsibilities following a nuclear war. The aim would be to achieve prior commitment by all parties to agree on who would control what.

PART E: MAJOR CONCLUSIONS

1. The yields from New Zealand's primary production systems would inevitably fall after a nuclear war in the Northern Hemisphere because:

   a) Should New Zealand experience falling temperatures and other climatic changes, the yields of vegetables, fruits, cereals and pasture crops would drop.

   b) With or without climatic changes, food production would fall once stocks of imported fertilisers, pesticides, animal health preparations and trace elements were depleted. (It is unlikely that we could fully replace these lost inputs with indigenous alternatives.)

2. Because New Zealand would no longer need to produce a large food surplus for export, we could tolerate a substantial decline in yields before we could no longer feed our population of 3.3 million. (We do not know how many migrants we could accept before carrying capacity would be exceeded.)

3. Factors other than the ability of the land to produce food would be much more important in determining whether or not people got enough to eat in the short-to-medium term. These factors include: whether or not the financial system collapsed; if and how food distribution systems continued to operate; whether or not attempts by central government to control and direct the economy were successful. All of these in turn would depend on human responses to the crises.

4. Impacts on the food production, processing and distribution systems would be much more severe in the event of an EMP. A key uncertainty is if and when the national electricity grid could be re-established.

5. In the long term, New Zealand's food production system would be likely to evolve into one in which farming was regionally diversified, so that the population within a geographical unit was self-sufficient in food. This might happen in one of two ways:

   a) By a centrally-planned and orderly transition from the current situation; this would require a strong central government able to plan and direct what food was produced where, and to exert control over the transport (including food distribution) sector, by way of fuel rationing, etc. Such a transition would be more likely to occur if there were no EMP.

   b) By undergoing a period of social chaos in which all national systems broke down (including financial and transport systems), and during which there was some starvation in urban areas, and the mass exodus of people from the cities out into rural areas. This would be more likely if an EMP were to disrupt national communications.

6. Associated with this change in the geographical distribution of people and food production, there would be a move to the use of "alternative" technologies as stocks of fertilisers, fuel and pesticides were depleted. The degree to which we would have to return to very primitive ways of doing things is unknown, e.g. whether we could produce some form of fertiliser industrially, or whether we would rely on biological manures.

This would also depend to some extent on whether or not an EMP permanently destroyed the national electricity grid.

7. Research into alternative systems of food production, processing and distribution could do much to help New Zealand prepare for the aftermath of a nuclear war, as could more general research into alternative social and financial systems. However, some of these alternatives are uneconomic at present. The problem is one of persuading decision-makers to fund such research.

8. If there is the political will to undertake contingency planning, a key objective of such planning would be to discuss, decide upon and obtain widespread commitment to the distribution of responsibilities following a war, namely who would take control and in which areas. Such planning must encompass the private and public sectors.

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