MINISTRY OF
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The 1997/98 El Niño Event:

Impacts, Responses and Outlook for New Zealand

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A review prepared for the Ministry of Research, Science and Technology

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Chief Executive

Note, June 2026: This electronic version of the report has been reconstituted by the author from paper and electronic materials available in June 2026. It aims to faithfully represent the original report, but there may be a few minor typographical differences to the original. This new version of the report may be found online on Earth Sciences New Zealand's website.

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The 1997/98 El Niño Event:
Impacts, Responses and Outlook for New Zealand

Executive Summary

A major El Niño event developed rapidly over the second quarter of 1997 and has been cited as the cause of many climatic disasters around the world. In New Zealand, eastern regions have been badly affected by a drought.

This report provides a scientific assessment of the event from New Zealand's perspective. It describes the El Niño phenomenon and how it affects New Zealand. It summarises the impacts reported both here and overseas.

The El Niño is a natural feature of the Earth's global climate system. El Niño events occur about 3 to 7 years apart, typically becoming established around April or May and persisting for about a year thereafter. The main impacts of El Niño events arise from shifts in global rainfall zones, resulting in droughts in some regions and floods in others.

At present (mid-April 1998) the El Niño event remains very strong, but overseas computer models suggest that it will slowly wane over the next few months and perhaps be gone by the end of the winter. However, caution is advisable as there is considerable uncertainty in climate prediction.

A global survey of impacts shows that extensive regions involving dozens of countries and millions of people have been seriously affected by the 1997-98 El Niño. Reported impacts include drought-induced food shortages, massive forest fires, thousands of deaths from starvation, flooding and diseases, and reductions in economic growth forecasts. The event has been compared to the large 1982-83 event, whose global cost was estimated at US$ 8 billion.

In New Zealand, the El Niño is typically associated with more southerly winds in winter, more south-westerly winds in spring and autumn, and more westerlies in summer. This results in cooler conditions nationally, and higher than average rainfall in the western regions and drought in eastern regions. This pattern has been generally present in the current event.

However, there are also large climatic variations arising from other natural unexplained and random causes which can swamp the "typical" pattern of El Niño influences. For example, the 1997-98 summer was very warm, culminating in the exceptionally warm month of February. This is not typical of El Niño summers.

A wide range of climatic impacts in New Zealand is evident from the survey conducted in this report. There are reports of significant pasture losses, production losses in animals, grains and fruit, tree deaths in native forests and plantations, and loss of water reserves in ponds, rivers, and aquifers. The farm gate cost to agriculture alone has been estimated at over $425M. The ecological costs are unclear but may be substantial in some situations.

Some impacts are positive; for example, drier conditions have led to reduced requirements for chemical pest control in horticulture, the wine industry reports an excellent grape crop, and the South Island hydro lakes have been full to overflowing.

Not all of the impacts are due to the *typical* El Niño pattern—some have been due to the abnormally high summer temperatures, for example. It is possible to say whether a climatic anomaly is *consistent* with the usual El Niño pattern, but it is not possible to provide a clearcut separation into El Niño and non-El Niño causes. This is not a problem, however, since it is the impact of the anomaly that is of prime importance, irrespective of the cause.

As a result of past research, there is a large body of scientific knowledge about how plants, animals, ecosystems, and industries react to climatic fluctuations. Experts and decision-makers can use this knowledge to apply climatic information and predictions to improve production, land use sustainability, and the management of risk.

A variety of El Niño response strategies have been used by sector groups, farmers and other decision-makers. These include such things as transporting stock to better watered regions, changes of planting and harvesting regimes, better irrigation management, altered application of fertiliser and chemical sprays, preparations to reduce forest fire risk, and the dissemination of information through industry magazines and meetings.

Climate research has provided a scientific basis for making El Niño predictions, but there are many sources of predictions, and users often face conflicting or inconsistent information. Moreover, there are grounds to doubt the scientific validity of some locally available forecasts. The organisational systems and linkages required to generate scientifically-valid, authoritative climate prediction information and to successfully apply it in users' fields remain undeveloped in New Zealand.

The 1997-98 El Niño serves to emphasise the need, and opportunity, to better fuse the various sciences, and the research and user communities, to more effectively monitor, predict and respond to drought and other climatic impacts.

No scientific view has been firmly established yet on how El Niño events might change under future climate change.

A practical link, however, is that El Niño events provide the opportunity to investigate how to adapt to future climate change, since climate change is expected to become evident through droughts, floods, heatwaves, etc. The 1997-98 El Niño event provides a excellent opportunity to gather information on how decision-makers respond to such climatic stresses, and on specific adaptations that were applied or developed.

1. Introduction

The current El Niño event has been widely cited as the cause of many climatic disasters around the world, including the drought that is affecting parts of New Zealand. Variations of climate can have large and costly impacts on communities and the environment, and can affect international trade.

This report provides a scientific assessment of the event from New Zealand's perspective, covering the impacts both here and overseas and the event's likely future behaviour. The question as to how many of the impacts are really attributable to the El Niño is considered.

2. The El Niño and other climate variations

How the El Niño works

The El Niño is a natural feature of the Earth's global climate system. Originally it was the name given to the periodic development of unusually warm ocean waters along the tropical South American coast and out along the Equator to the dateline, but now it is more generally used to describe the whole "*El Niño - Southern Oscillation (ENSO) phenomenon*", the major, systematic global climate fluctuation that occurs at the time of the ocean warming event.

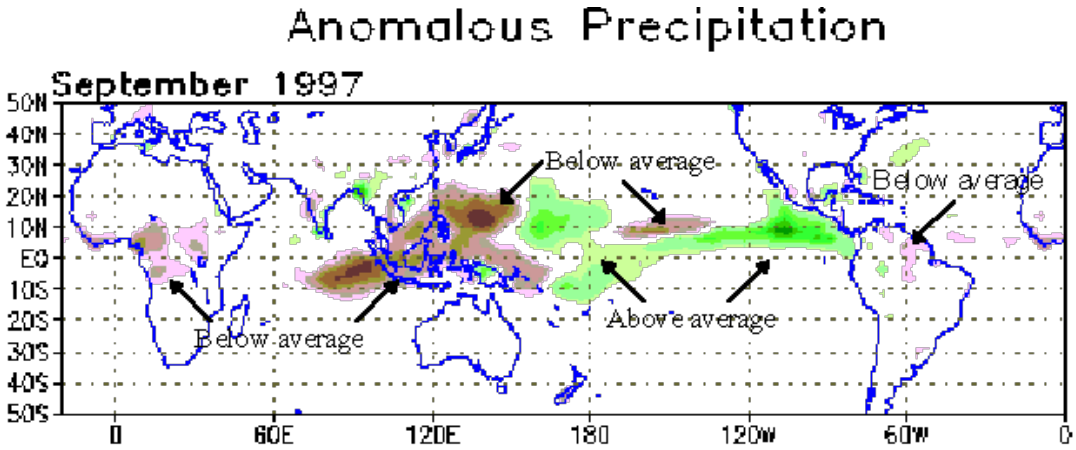
The Southern Oscillation refers to a seesaw of atmospheric pressure changes that occurs between the southeast Pacific Ocean and the Indonesian region. Coupled together and reinforcing each other, the El Niño's oceanic and atmospheric components cause major shifts in the patterns of winds, cloudiness and rainfall, especially in the Pacific basin. A schematic of the phenomenon is provided in Annex 1.

El Niño events occur irregularly, about 3 to 7 years apart, typically becoming established around April or May and persisting for about a year thereafter (so far, the 1997-98 event is following this pattern.) Each event represents a "release" after which the conditions in the Pacific basin must "build up" over several years in preparation for the next event.

As an El Niño event develops and reaches its extreme, the shifts of the globe's weather zones and rainfall patterns (figure 1) result in widespread droughts in some regions, and heavy flooding in others. The regions most affected are the tropical and sub-tropical regions of Indonesia, Australia, the Pacific Islands, the Americas, and southern Africa. The patterns of tropical cyclones and storms also change.

A New Discovery

It is only in the last 30 years that climate research has revealed the connection between the oceanic and atmosphere parts of the ENSO phenomenon. Before then, it was not realised that the long-recorded failures of the monsoons which have killed millions of people in India and China in past centuries, and the dramatic failures of fisheries on the other side of the world, along the Pacific coast of South America, were intimately related. As recently as November 1972, a National Geographic article describing the recurring serious droughts affecting northeast Brazil made no mention of the 1972 El Niño event. The global significance of El Niño became widely appreciated after the very strong 1982-83 event (e.g. see National Geographic, February 1994). It is now known that El Niño events are clearly present in climatic data over the last 130 years and can be traced back for hundreds of years in written historical records.



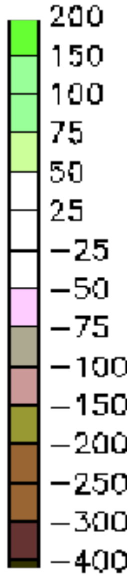


Figure 1: Rainfall anomaly pattern for September 1997, as difference in millimetres from September's historical long term average. (Source: US National Oceanic and Atmospheric Administration.)

Global impacts of El Niño

The economic damage caused by the 1982-83 event, regarded as the strongest event of the century, has been conservatively estimated at more than US$ 8 billion, of which US$ 2.5 billion was due to drought and fires in Australia. Both developed and developing countries were affected. Up to 2000 deaths (70 of them in Australia) have been linked to this event.

Historically, El Niño-mediated climate and food changes may have led to pandemics, such as of the plague and influenza, and may have been contributing factors in historical events such as the Black Death and the French Revolution, according to speakers at a recent conference in Canberra. In some areas, El Niño famine and disease may have reduced the population by 50%. Monsoon failures associated with the El Niño are known to have caused hundreds of thousands of deaths from starvation in India and China in recent centuries.

Since the 1982-83 event, two further events have occurred, the moderate 1986-87 event, and the unusually prolonged and erratic 1991-94 event. The current 1997-98 event has been described as comparable to the 1982-83 event. Each of these events is evident as a negative excursion of the Southern Oscillation Index (see figure 2.)

Biological and social responses

Biological and social systems can react to El Niño in complex ways. Some systems may easily tolerate moderate climatic stress, but react dramatically if conditions reach some higher threshold, with rapid death of plants, outbreaks of pests and diseases, widespread forest fires, or failures of key elements of economic infrastructure. Vulnerability is usually seasonally dependent—e.g. drought and major fires are worst during the dry season.

Some impacts, such as an explosion of a predator population, or an epidemic of malaria, may be slow to develop and may not become apparent until well after the event. Climatic stresses may expose or seriously magnify pre-existing environmental or social situations or problems, resulting in unexpected major impacts. The extensive scale of the forest fires and air pollution in South East Asia this year is a good example of this.

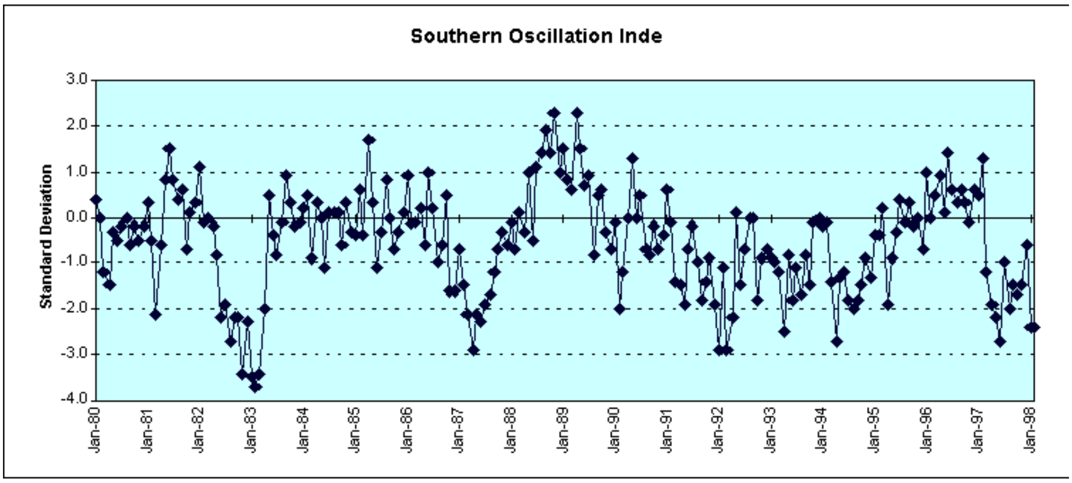


Figure 2: A Plot of Southern Oscillation Index (SOI) derived from pressure measurements at Tahiti and Darwin. The negative excursions correspond to the El Niño events of 1982-83, 1986-87, 1991-94, and 1997-98.

How New Zealand is usually affected

New Zealand does not lie in the any of the high-impact regions, but its climate is affected by changes in the atmospheric circulation (winds). In El Niño years, New Zealand tends to experience stronger or more frequent winds from the west (in summer), southwest (in spring and autumn) and south (in winter).

Increased westerlies lead to drought in east coast areas and heavy rain in the west, while increased southerlies bring colder conditions, both to the land and the surrounding ocean. Southwesterlies provide a mix of these effects. Figures 3 and 4 give examples of how summer rainfalls and temperatures vary with the main ENSO indicator, the Southern Oscillation Index.

Between El Niño events, there often occurs an approximately opposite extreme known as a La Niña event. La Niña events have weaker impacts on the climate. New Zealand tends to experience more north easterly winds, which brings more moist, rainy conditions to the northeast parts of the North Island. The last La Niña event was in 1996.

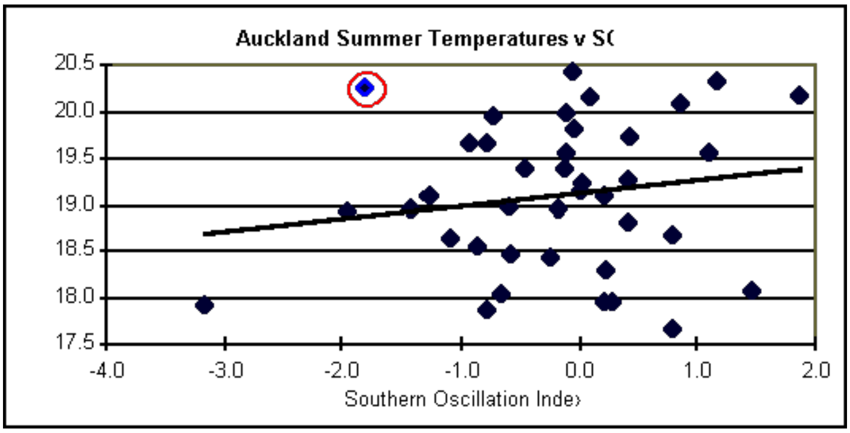
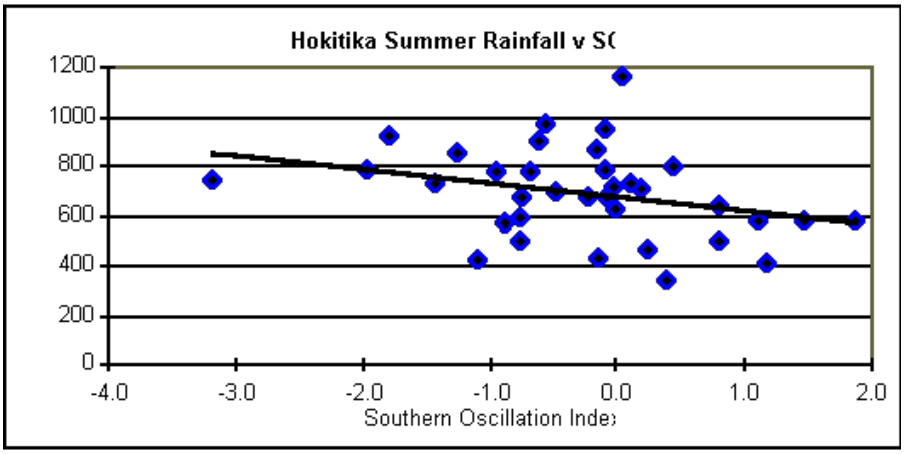


Figure 3: Plot of Auckland summer temperatures (°C) versus the Southern Oscillation Index (SOI) for 1950-98. Amid much variability, there is a tendency for temperatures to be lower during El Niño events (when the SOI is negative) owing to more frequent winds of southerly origin. A similar picture occurs throughout New Zealand. The ringed data point is for the recent 1997-98 summer, when temperatures were unexpectedly high.



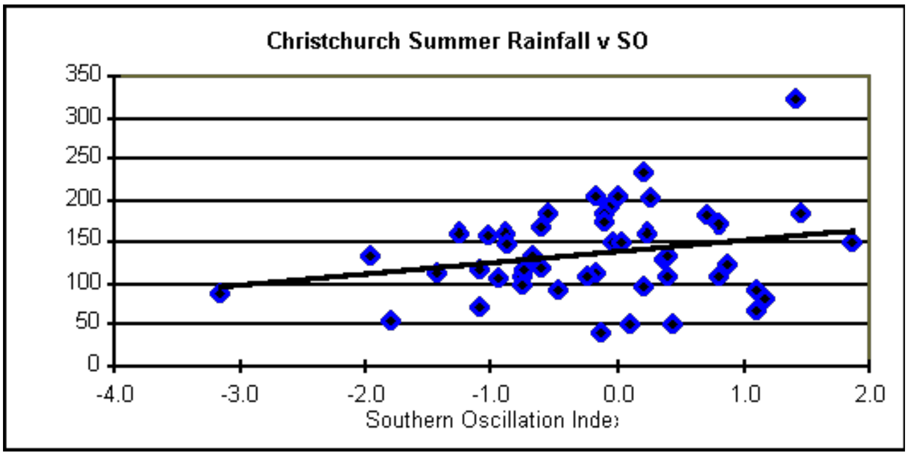


Figure 4: Plot of summer rainfalls in mm for Hokitika (top) and Christchurch (bottom) versus the Southern Oscillation Index for 1950-98. Amid the high variability, there is a general pattern of higher rainfall on the West Coast and lower rainfall in the east during El Niño events (when the SOI is negative). This leads to drought in eastern regions. The cause is the generally more frequent and stronger winds from the west.

El Niño is not the only factor

While the El Niño is important to New Zealand's climate, it does not explain all of the anomalies and variations experienced. Figures 3, 4 and 5 show that there is a great deal of variation that is not related to the Southern Oscillation Index. Other unexplained or random factors are the cause of climatic variations as large as those from El Niño. For example:

- East coast droughts may be common during El Niños, but they can also occur during non-El Niño years, as happened in the severe 1988-89 drought.
- Serious east coast droughts do not occur in every El Niño.
- The districts where drought occurs varies from one year to another, and from one El Niño to another (though some are more consistently affected than others.)

This means that when an El Niño is present, we cannot be sure it will produce "typical", average El Niño effects. We cannot be sure about whether the 1997-98 El Niño is the real cause of all the climatic anomalies or problem being experienced. However, there is sufficient statistical evidence of El Niño relationships in past records to enable useful predictions, management actions and planning to be undertaken, based on the probabilities.

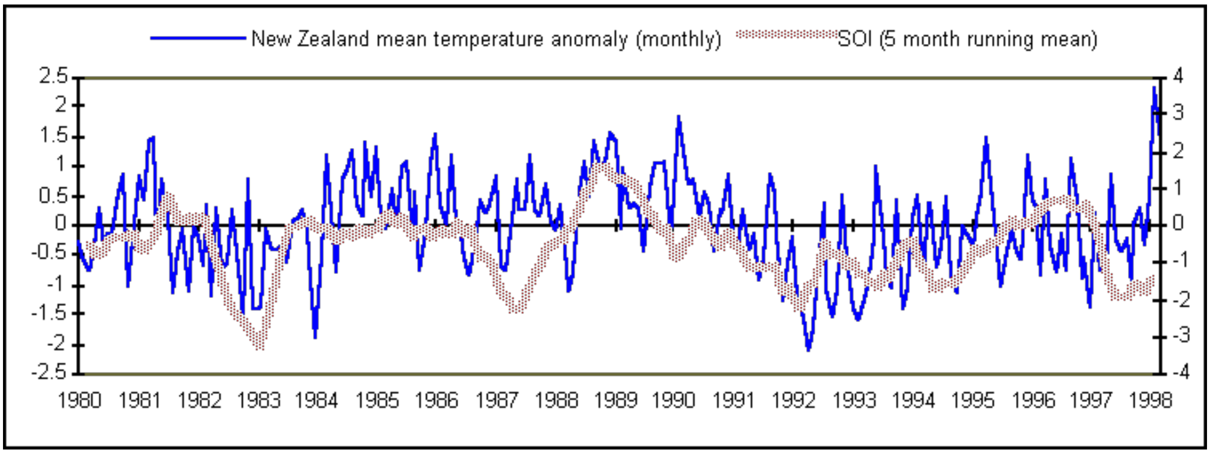


Figure 5: Plot of monthly anomalies of temperature averaged over New Zealand (•C, scale at left), and the Southern Oscillation Index (scale at right). Cooler conditions tend to occur during El Niño events (i.e. when the SOI is low), but there is also a large amount of month to month variability that cannot be explained by the event and cannot be predicted.

The chances of an El Niño causing a drought at a place can be found by studying past climate statistics. If rainfall is lower than average in 7 El Niño years out of 10, then we can conclude that droughts are likely. But there is also the statistical chance, in 3 out of 10 El Niño years, that the rainfall will go against the trend and be higher than average. The actions one takes must be based on these probabilities.

Is ENSO affected by climate change?

Some research indicates that the frequency (and perhaps intensity) of El Niños will alter under future climate change, but as yet a scientific consensus has not been established on this issue, or on whether the relatively more frequent El Niños of the last two decades is related to the slow rise in global temperatures this century.

3. The 1997-98 event and its global impacts

Development of the event

In March 1997, signs appeared in the tropical Pacific region that the weak La Niña episode of the previous year was disappearing and that an El Niño event might be about to emerge. By June, the climatic data and computer models firmly supported the development of an event, and thereafter conditions changed very quickly to form a classic El Niño event by July.

The rapidity of the development was surprising and led some commentators to predict that the event would be the greatest of the century. However, conditions stabilised at the level of a very strong event, comparable with the 1982 - 83 event.

The first major impact reported was the increasingly severe drought affecting the Indonesian and Papua New Guinea region over the second half of 1997 (this is evident in figure 1.) Since then, many other impacts have been reported, though not all of these are necessarily directly linked to El Niño influences. The following selection of reports from newspapers and the world wide web provides a global context for considering the impacts on New Zealand (which are listed in section 4.)

Selected national and regional impacts

New Guinea food shortages: Food shortages and looming starvation formed a major disaster in Papua New Guinea. Australian government assessments put the number of people at risk at approximately 1 million, and a major international food aid effort was mounted. Famine has also occurred in Indonesia's Irian Jaya, where 500 people are reported to have died.

South East Asian food production: Agricultural production is expected to drop in Indonesia, Malaysia, and Philippines, in some cases by up to 50%. Some South East Asian countries have reduced their projected GDP growth figures as a result. Food shortages are likely to have exacerbated Indonesia's currency crisis.

Indonesian fires: Dry conditions led to the development of large-scale uncontrolled wildfires in the tropical rainforests of Sumatra and Borneo, Indonesia, that burned out of control for weeks, creating unprecedented smoke pollution affecting the whole south east Asian region. In the worst hit-areas of South-East Asia, visibility was at times down to less than 100 metres, and serious respiratory problems occurred among the population.

South Pacific tropical cyclones: The number of cyclones this cyclone season (October to April) is likely to beat the record 16 cyclones (set in the 1982-83 El Niño event). There has been a shift in the pattern of occurrence toward eastern areas such the Cook Islands and French Polynesia. This is typical of strong El Niño seasons.

Other tropical cyclone zones: There was a nearly complete shut-down of Atlantic tropical storm and hurricane activity after July 1997, while an expanded area of favourable conditions occurred over the eastern North Pacific, where Cyclone Linda was reported as the most powerful cyclone ever observed.

South American drought and fires: Very dry conditions characteristic of El Niño have been reported for Venezuela, French Guyana and the northern states of Brazil. Fires arising from subsistence agriculture have burned out of control and are threatening the habitat of indigenous forest peoples. Around 100,000 people are at risk. About 500,000 ha of savannah have been destroyed. Guyana is severely affected by drought. Water shortages there have halted gold mining operations, water conservation measures have been instituted, and measures based on El Niño forecasts have been put in place to minimise effects on agriculture.

South American rainfall: Wetter than normal conditions have occurred throughout large parts of Pacific coastal, central and southern South America, with flooding in Ecuador, Peru and central Chile. Some locations have received several times their total average annual rainfall in a single day. In Peru, over 80 people have been killed from greatly increased rainfalls, floods and mudslides. Public policies and works implemented after the disastrous 1982-83 event are credited with significant reductions of the impacts this year.

East Africa: During October-November, rainfall in equatorial eastern Africa was exceptionally heavy. Kenya has been particularly hard hit by flooding. Reports state that over 1,500 people have died of malaria arising from the flooding, and more than 500 people died from outbreaks of Rift Valley fever, reportedly through failure to control the disease owing to floods. Severe flooding in Somalia was the worst in three decades and resulted in more than 1200 deaths.

Coral bleaching: The El Niño's warmer ocean has raised sea temperatures to above the threshold for coral bleaching in the Galapagos Islands.

Canadian snowstorm: January's moisture-laden icestorm in eastern Canada and US New England states caused extraordinary damage to power lines and trees, through the weight of accumulating ice, and has been billed as the worst-ever natural disaster in Canada's history. The storm has been partly linked to El Niño shifts in North American weather patterns.

Australia: Very dry conditions affected much of Australia in 1997, and widespread bushfires in New South Wales in November affected 400,000 hectares, causing loss of property and the deaths of two fire fighters. By January 1998, drier-than-normal weather continued to affect southeast Queensland, but much of tropical Australia recorded average to above-average rainfall in January and heavy rainfall across the far north signalled a declining influence of the El Niño's there. Generally, the drought has not been as bad as in previous El Niños.

California storms: Wet, stormy weather is typical for California during El Niños, but these conditions did not appear until early this year, when a powerful storm brought strong winds, high coastal waves, torrential rains, and widespread flooding.

Californian dairy industry: The El Niño has affected the milk industry, leaving more than $8 million worth of cows dead from recent storms. Milk producers in the giant dairy park east of Los Angeles have lost more than 9,200 animals since February 9, according to the California Milk Producers Council. The situation could eventually affect milk prices, experts said.

California cost estimates: California farm damage amounted to $90.8 million and was still rising, according to a Food and Agriculture Department report. In addition, the January 1997 floods cost $245 million.

Florida vegetables: El Niño's torrential rains and powerful storms have affected Florida vegetable farmers this year, causing damage to potato plants, corn, and cabbage crops. Up to 30 percent of Florida's winter vegetable crops are at risk, according to published reports. Past research shows that yields of tomatoes, bell peppers, sweet corn and snap beans plunge during the winter harvest in El Niño years and prices rise by 20-30%.

Termites in Arizona, California and Florida: Pest exterminators are blaming El Niño for the early emergence of termites in these states, owing to warmer temperatures. The National Pest Control Association notes that annual termite damage exceeds the costs of fires, floods and tornadoes combined, and that homeowners spend $2 billion each year to control termites.

Business impacts: The impacts described above will have significant impacts internationally on commodity prices, trade, public accounts, and farm and business profits. Also, decisions based on predictions of specific El Niño impacts that have not materialised will also have led to losses. A number of companies have blamed the El Niño for their poor performances, but some commentators have questioned whether this is a convenient excuse for other failings.

Global temperature increase: El Niño events cause the global climate to be a little warmer in the year they occur. According to the UN World Meteorological Organization, the current strong event was a contributing factor in the record high global temperature observed in 1997.

4. Impacts and responses in New Zealand

There is no formal process of monitoring and assessment of climatic impacts in New Zealand. At the request of the present study, experts in various sectors forwarded information on the situation at the end of March 1998. The information collated and summarised in this section forms the best quickly-available material at this stage, but it is not comprehensive and it may be inconsistent. Also, conditions are changing each week. It is not possible to clearly link all the reports to actual climate anomalies, or to clearly link all impacts with the El Niño.

Climate

A month by month summary of climatic conditions since the start of the El Niño event is provided in Annex 2. The climate records show two main features.

- Typical El Niño anomalies are generally present from July onward. There were more frequent or stronger southerlies in winter and more frequent or stronger southwesterlies and westerlies in spring and summer. Western areas generally were wetter and eastern areas drier, and cool anomalies were often present. The extent of the drought as at the end of March, is indicated in Figure 6.
- There is considerable variability, from month to month and place to place. This has resulted in some significant deviations from the "typical" El Niño patterns. In some months and regions, high temperatures went against the El Niño trend (February's record breaking heatwave is not typical of El Niño summers.)

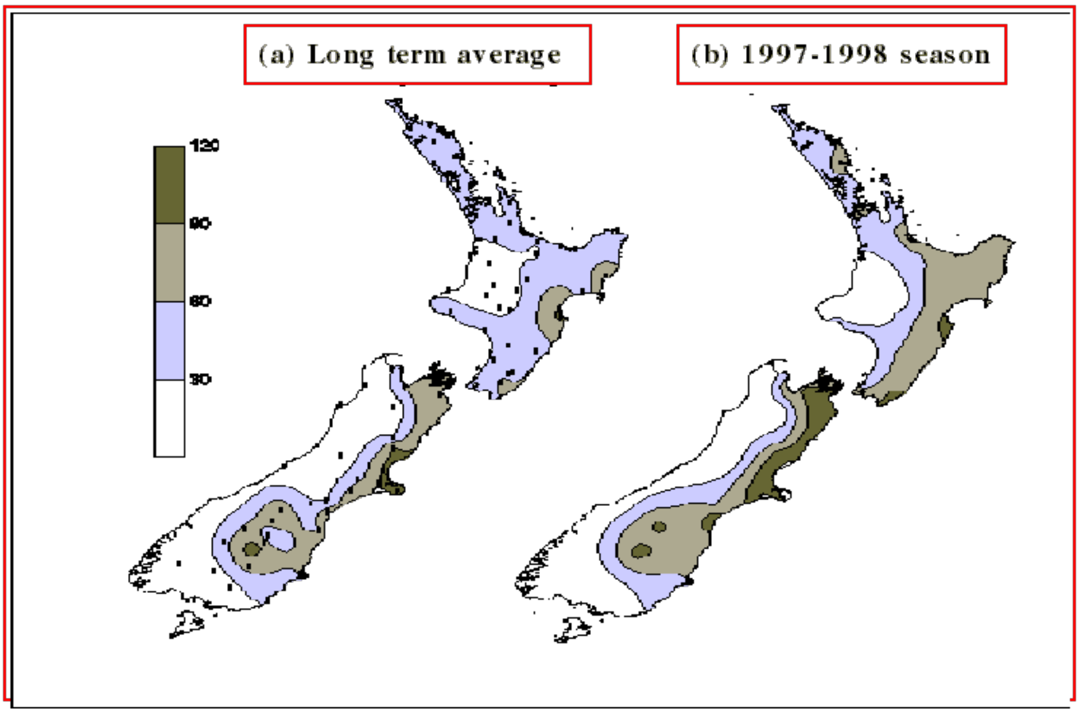


Figure 6: Maps of the number of days (up to 31/3/98) for which soil moisture is insufficient for plant growth; comparing (a) the long-term average with (b) the current 1997-98 situation. The data are calculated from climatic data, using the climate stations marked as dots on the left. The figure shows the greater than average extent of drought conditions in east coast areas from Canterbury to the Bay of Plenty during the current season.

Some dry regions have experienced rainfall at various stages which has reduced the drought (though sometimes only temporally), e.g. during February in Auckland, Bay of Plenty, Nelson, western Marlborough, parts of South Canterbury and east Otago, and during March in Marlborough and Canterbury. However, warm westerly conditions have generally prevailed through the autumn up until the date of this report (mid-April), and drought conditions have generally worsened.

Agricultural economic impacts

On 21 April 1998, the Ministry of Agriculture and Forestry (MAF) estimated the likely cost of the drought on farm gate returns at $256 million for 1997/98 (June 30th end of year), plus $169 million for 1998/99, giving a total cost of $425 million (see Annex 3 for details.) These represent about 2.5% of 1997/98 farm gate returns and 1.5% of 1998/1999 farm gate returns.

Downstream valued-added agricultural production, whose value is about three times the on-farm returns, will be affected, which implies a total national cost of more than $1B.

The MAF calculations refer to the loss of income (after stock sale and purchases) and direct drought related costs, and include estimates for the dairy, arable and horticultural sectors. They attempt to isolate the impact of the drought only, and to exclude any costs of falling product values due to the Asian currency crisis etc. From farm monitoring, MAF calculate the number of sheep and beef affected to varying degrees by the drought conditions.

Conditions appeared to have deteriorated significantly since the earlier analysis by MAF on 16 February 1998. The total costs have risen, mainly owing to higher than anticipated pipfruit losses and higher carry over effects for next year for sheep and beef. About 45% of the nation's stock numbers are now affected. A newspaper report on 18 April, quoting MAF, put the farm gate cost to Hawke's Bay alone at $150M for the two seasons, which included a 45% reduction in the region's apple export crop this season.

Large impacts of climate on GDP

Previous studies have shown that the impacts of El Niño events, other year to year climate variations, and storm events in New Zealand are largest for the agriculture, horticulture and hydro-electricity sectors. A 1996 MoRST-commissioned study estimated that the average annual financial impact amounted to more than one billion dollars (1993/94 data), which was equivalent to about 1.6% of GDP.

Pastoral

Moisture stress is a major factor limiting potential pasture production in New Zealand, and this is generally worsened during El Niño events. The current El Niño has reduced pasture growth rates in many eastern and southern areas with the most extreme conditions evident in Marlborough, North Canterbury and parts of the Wairarapa and Hawke's Bay. The northern region of the North Island, Gisborne and Wairarapa are better positioned than anticipated. Marlborough is the worst hit of any region.

However, the structural changes in the industry over the last decade which have resulted in lower stocking rates, have reduced the pastoral industry's vulnerability to feed shortages and drought generally. Furthermore, farmers have acted early to reduce their exposure, by selling stock and transporting animals to better watered regions.

Higher than average temperatures, which are not typical of El Niño events, have reduced pasture growth rates. The optimum temperatures for the predominant pasture species ryegrass can be exceeded in hot, dry summer conditions. The combination of low soil moisture, high solar radiation, and high air temperature can result in soil surface temperatures exceeding 50°C; prolonged exposure to these conditions results in severe stress and death of pasture plants.

Climatic stress can also exaggerate the effects of pests such as grassgrub and clover root weevil. However, alternative pasture species (including tall fescue, cocksfoot, phalaris, chicory, Caucasian clover and hybrid clovers) have been developed over recent years and some have demonstrated excellent performance in the current drought.

Ryegrass staggers has been severe in the drier parts of the country. This arises from a fungus (endophyte) that lives on ryegrass. This fungus is also an important factor in the pest resistance and drought tolerance of ryegrass. Severe heat stress in cattle when temperatures are extreme is also associated with the presence of the fungus and has been widely observed in dairy cows in northern New Zealand this year. A new endophyte to be released soon is expected to largely eliminate these problems.

Higher temperatures this summer appear to have exaggerated the trend toward greater incidence of sub-tropical (C4) grasses in northern New Zealand (arising from temperatures rises over the past twenty-five years.) These grasses are low quality and less desirable for livestock diets. Current research is being directed at reducing the adverse effects of C4 grasses and breeding improved grasses capable of utilising the higher temperatures.

Dairying

As the 1997/98 dairy season draws to a close, current expectations are that the national production of milk solids (MS) will be down by 20 million kg MS, relative to initial industry forecasts of 910 million kg MS for the season.

Climatic conditions during spring were very favourable for dairying across much of New Zealand and gave a good start to the season. Peak milk production (September - November) was some 12% higher than last season, and the highest on record.

Summer climatic conditions were less favourable, but the impacts were variable. Drought conditions existed in the north and east of New Zealand, where the majority of New Zealand's milk is produced. However, very favourable conditions were experienced in the west and south, leading to good summer milk production in those regions.

Overall milk production for the period December - March this season was 7% down on 1996/97. This trend will continue for the remainder of the autumn since the culling of all surplus animals from milking herds during the summer leaves smaller numbers of animals to produce milk during autumn.

Historically, the flow-on effect of droughts into following seasons is not great. The climatic conditions experienced this season have made life difficult for many dairy farmers, but generally they have not been widely outside the expected range of year to year variation.

Grain

A mixed picture emerges for grain production during the summer. Yields of barley and wheat in dryland (non-irrigated) areas appear to be down by from 10% to as much as 50%, depending on location, cultivar, and sowing date, but yields were good for irrigated farms.

The overall production loss for wheat may be as much as 25%. Wheat quality was generally high, though in North Canterbury the strong vegetative growth of some crops from early spring rain produced very small grains when the rains did not continue.

Barley producers report that in irrigated farms, production was as expected and malting quality was high, but for dryland farms, the yields were down about 25% and the malting quality was poor owing to the grain nitrogen content being too high.

While it may have been a disastrous year for some farms, it seems that for Canterbury grain farming as a whole the season's losses were comparable to past fluctuations. In Marlborough, where rainfalls have been less, cropping is a minor activity and it is the effects on pastoral farming that are likely to have the prime financial impact. Since harvesting in Canterbury is largely completed by the end of January, the impact of rainfall shortage thereafter is minimal. Farmers just wait for the rains to prepare for autumn planting.

Grain farmer response to drought predictions

Reports indicate that farmers reduced fertiliser inputs in response to the drought and drought warning, which saved money without affecting crop yields. Research indicates that the early sowing of suitable cultivars is the best insurance against drought, mostly because the grain growth is earlier thus reducing the effects of later severe drought conditions, but it is not clear whether any farmers applied this strategy.

Horticulture

The warm, dry conditions prevailing during the summer in most horticultural regions has generally lead to reduced disease problems and improved quality in most sectors.

For apples, sunburn and overheating from high summer temperatures have been a particular problem in Hawkes Bay, Marlborough, Nelson and Canterbury, leading some orchardists to leave 40% of Royal Gala and Gala apples on the trees unpicked. Water Core has caused losses in Cox's Orange Pippin apples amounting to about 80% of the crop in Hawkes Bay and 20% in Nelson, and has also affected other cultivars and regions.

Sunburn and watercore are expected to lead to a loss of at least 1.5 million cartons (mostly in Hawkes Bay and equal to about 8% of the national apple crop), which would otherwise have been exported for a gross $30-$40m. This loss may be partly offset by good export prices. (Mid-April estimates by MAF have put the estimated loss at 1.8 million cartons.)

Lack of colour development due to lack of cold nights seems to be affecting all cultivars and has lead to an alternative lower colour standard being offered by ENZA for the export of the important Braeburn cultivar. Poor colour is likely to lead to lower export prices.

The early Royal Gala crop was harvested when temperatures were very high, which compressed the harvest period to about 2 weeks instead of the usual 3-4 weeks, and created difficulties in handling fruit and reducing fruit temperature for cool storage. Black spot (which requires moisture) has been low this year in Hawkes Bay and this has meant fewer fungicide applications and lower chemical costs for some farmers, but Codling Moth has been more of a problem, possibly because of higher temperatures. There is increasing concern about Lenticell Blotch, a surface marking on the apple which does not show up until well after harvest and which is believed to be drought related.

Reports on pears indicate that the lack of cool nights has reduced their russet (a similar problem to the lack of colour in apples) which could lead to lower prices. Wind damage to fruit with skins which mark easily, such as the Comice pear, has occurred in Nelson.

Grape growing regions appear to have had an excellent year so far due to the warm, dry conditions, and in Hawkes Bay the vintage is reportedly the best in 15 years. The anticipated higher sugar content and smaller fruit should combine to produce an excellent vintage. Drier conditions mean less spray use and lower chemical costs. The drought in Marlborough has not been a major problem, as irrigation from groundwater has been generally adequate. The only negative effect has been increased bird damage - birds use the fruit as a source of water in dry periods. The overall positive impact on this $150M industry may be as much as $10M, and an exceptional vintage could have large long-term benefits for the $40-50m export market.

Kiwifruit are showing good growth in the Te Puke region, and the quality (higher soluble solids) is likely to be better than usual. Good quality peaches and nectarines in Otago and Waikato and a good melon crop in the Gisborne region have been attributed to warmer than usual conditions, while a poor crop of apricots in Otago has been ascribed to poor weather at pollination. Berryfruit is showing good sugar levels in fruit owing to warmer, drier conditions and a very good year is expected, especially in Northland, but bird damage has increased. The cherry crops in Otago and Marlborough are excellent, with good-sized fruit and little splitting, because of warm dry conditions, though some wind damage has occurred in Marlborough.

Sphagnum Moss on the West Coast has benefited from the combination of wet and warm conditions. The value of exports varies wildly from year to year (up to $18m) partly because of weather conditions.

Vegetable prices have been high recently, which is an indication of drought impacts. Irrigated areas would be little affected; production crops of sweetcorn, freezer pea, beans, potatoes, onions in Canterbury are irrigated and generally have not suffered. Dryland production areas will be affected, however. Statistics New Zealand has stated that higher vegetable prices were a major factor in the rise in the most recent Consumer Price Index.

Forestry

Climate has direct effects on wood growth, survival of trees (especially young plants), fire and windstorm risk, forest heath, and field operations. Drought on the east coast of both islands is the main concern. There has been little reported wind damage to forests apart from approximately 60 ha damage in the Otago/Southland region caused by a storm on 29-30 November 1997.

Radiata pine has not grown much in height or diameter this season, but neither has it died, unless the trees were young (up to 3 m tall, less than 4 years old) or planted on shallow soils. The growth in tree diameters at Eyrewell Forest has dropped to values typical of the 1982-83 and 1988-89 drought years. The greatest casualties have been to Eucalypts, where large trees have died in many places. Those of the ash group will not recover. Douglas fir is also badly affected, with widespread death. Poplars and willows have lost their leaves, but permanent damage is not expected. Cupressus macrocarpa deaths have been reported, but the economic potential of this species is not affected.

Reports from Canterbury indicate extensive losses of planted trees and shelterbelts. Many trees up to 25 years old have died, and few farms in North Canterbury are unaffected. Pinus radiata has been little affected, but Eucalypts and willows have been badly hit. Despite recent rain, tree deaths may continue to occur over the next few months and the full effects may not be fully known until next spring, owing to the time to recharge soil water storage.

This season, eastern areas of the country in particular have experienced significantly higher than usual fire danger risks, but to date (mid-April 1998) no forest fires of note have occurred. Drier and windier conditions associated with El Niño events increase the fuel availability, the potential for rapid spread and more intense fires, and hence the difficulty of fire suppression operations. Fire risks in the wetter south and west of both islands have been lower than usual.

Forest industry preparation for El Niño fire season

Over the last few years, forest owners, rural fire protection agencies, and forestry researchers have developed active monitoring and response capabilities for fire risk, and this season have maintained a higher alertness in response to predictions of the El Niño and to the emerging climatic conditions. This includes the use of the key climate-based New Zealand Fire Danger Rating System (NZFDRS), a 21 station climate network, and the provision of articles to industry journals on fire risk management.

Fisheries

Observations of fisheries changes in the present El Niño are very sketchy, but it is known that fish populations and their food sources, predators and competitors, are affected by climate-related changes in sea temperatures, wind patterns, ocean currents and upwelling. For example, the larval and juvenile survival of snapper and gemfish is generally more successful in warmer years, while hoki is more successful in colder years. Effects may not be immediate; an effect in one year, say on the food source for juveniles, may not become evident until the mature fish population is exploited some years later.

In the 1982-83 El Niño, in some areas the catches and catch-rates of barracouta, red cod and blue warehou appeared to increase, while those of squid declined. Migratory oceanic pelagic species like tuna shift south in warmer years. The arrival in New Zealand waters of Chilean jack mackerel is thought to have been related to the two major El Niño events in the 1980s. This species was previously unknown here but is now a dominant feature.

Usually in El Niños, the more frequent southerlies and southwesterlies cause the oceans to be colder than average, but this season, temperatures have been generally above average, especially around the North Island, and therefore, the usual effects such as weaker snapper year-classes may not have occurred. There are indications that the distribution of tuna species is a little different in northern waters, with more bigeye tuna, and yellowfin tuna swimming deeper. There have been reports of a major shift of deeper water species such as silver warehou and hoki into shallower coastal water off the east coast of the North Island, and of a low squid catch around Auckland Island. More reports of "fish kills" and strandings may be partly due to better reporting, arising from the high publicity for the El Niño.

Toxic algal blooms have occurred in previous El Niño events, and in 1998 blooms developed in the Hauraki Gulf and east of Wairarapa in January, but disappeared in February, possibly because of February’s unusual climatic conditions. Toxic algae in Wellington Harbour in March poisoned swimmers and had a major impact on the harbour’s marine animals. The role of climate in the complex biology of algal blooms is still not very clear, however.

Salmon fisherman have had a frustrating season because the main salmon rivers on South Island east coast have been too high and turbid to be fishable. When the rivers have not been in flood the water levels often have been too low and too warm.

Industry, infrastructure, urban areas

Higher air temperatures, by as much as 3 °C above average, have led to a heavier demand for urban air-conditioning and hence for electricity, and to higher soil temperatures. It is not yet clear whether these factors played any role in the failure of the buried electricity cables supplying the Auckland central business district.

In Manukau City, a major effect of the hot, dry and windy weather has been a dramatically increased number of complaints and severity of environmental problems caused by dust arising from earthworks at subdivisions. Manukau City possibly has the largest number and biggest area of new subdivisions being worked in New Zealand at present. Complaints to the city's environmental health section rose from 14 in the 1996/7 season to 54 in the current 1997/8 season, and for several days it was necessary to halt all works due to the dust.

Air quality and air pollution in urban areas usually worsens as temperatures rise, but decrease as the wind increases. There is no data available yet to show what happened this summer. In past El Niños, it has tended to be generally less windy in Auckland, which would have led to more high pollution events. Year to year variations from El Niños therefore have the potential to mask real trends and thus lead to inappropriate longer term policy decisions.

The occurrence of more extreme events leads to more claims of damage, and closer attention to the range of natural climate variability and long term risks by those involved in initiating or protecting major investments, such as dams, orchards, subdivision, and large industrial plants.

Health

Climate is known to play an important role in human health, particularly in asthma, heat stress, food poisoning, vector borne diseases, and even social behaviour. A significant impact is the stress on farmers, their families and the rural community in drought-affected areas, but otherwise to date there have been few if any reports of health impacts linked to the current event. This is not surprising since health status is affected by many other factors, and good data and research are required to identify the climate influences.

Water and soils

Severe reductions in water levels in streams and ponds have been observed in many eastern areas, and many creeks and small tributary streams are now dry. Ponds have become stagnated and clogged with weed, and are often strongly polluted from stock spending more time in them. Dragonflies appear to be breeding well in these conditions. Hundreds of dead eels were found in dried out coastal lakes east of Woodend near Christchurch.

When polluted ponds are first flushed following rain, a pulse of polluted nutrient rich water will flow. In eastern areas of the North Island, stock ponds have dried up for the first time since the drought in 1982-83. In some cases, the pond water capacity has been found to be much lower the expected, owing to sedimentation over the years, and farmers have used the opportunity to re-excavate the pond to restore the water holding capacity.

With better access to the dried-out water courses, stock are causing increased damage to stream banks, which will increase the sediment input to stream channels. Shrinkage cracks in hillslope soils in eastern regions of the North Island are the worst observed in many years. If the drought is followed by a period of heavy rainfall then significant land sliding is likely.

Along the West Coast and alpine chain, the increased westerlies of El Niños bring wet conditions and copious flows into the rivers that drain both sides of the Main Divide. High river flows have resulted in modifications to West Coast water courses. At Punakaiki, surges of water have passed right over gravel ridges as indicated by the disappearance of ground vegetation, while at Okarito, major re-workings at the openings of lagoons have occurred. There are likely to be major impacts on lagoons and adjacent wetlands along the entire west coast of the South Island.

On the eastern side of the Divide, the major rivers are fed by spillover rainfall from the westerlies and have been high and often in flood. The Waimakariri and Rakaia have been continually flooded. The controlled hydroelectric storage lakes (Tekapo, Pukaki, Hawea, Te Anau and Manapouri) were full to spilling in March, and flood warnings were issued for the lower Waitaki River. Scientists and engineers have used El Niño - river flow relationships to provide forecast advice on flows and lake levels to electricity sector companies.

The large Canterbury aquifers fed directly from high country areas have maintained their water storage despite increased abstraction of water for irrigation. However, in the drier areas between the main rivers, and where groundwater depends on local rainfall, there have been many reports of low water level in wells and rivers. In smaller aquifers, e.g. in the Pareora catchment near Timaru and in North Canterbury, water availability has become very limited.

Overall, there has been a very significant fall in the level of water tables in Marlborough and Canterbury. In Canterbury, an unusually high number of restrictions are in force on river water abstraction for irrigation (a record 20 rivers, versus on 4 rivers previously).

In Nelson, rainfalls had been below average for nearly a year, and some of the region's aquifers were at risk of saltwater intrusion. February rainfalls have alleviated this problem, but the Moutere River remains dry along much of its length, with the Deep Moutere Aquifer at low levels and rationing in force.

Hydroelectricity in good shape

With rivers in flood and lakes spilling, the South Island hydroelectricity system is currently is good shape to face the winter, when demand normally rises and rainfall slackens. There is currently no sign of a repetition of the 1992 electricity crisis that occurred during the 1991-94 El Niño.

Ecosystems

In the drier eastern areas, prolonged and persistent periods of strong westerly winds, high temperatures and low humidity have been common. Vegetation and other biota are very vulnerable to such conditions, especially in the smaller forest remnants and plantings.

Exceptional dieback in native vegetation has been reported in eastern areas of both the North and South Islands, e.g. in regenerating stands in mixed *Nothofagus* forest in the Ashley Gorge, North Canterbury; in tawa, lemonwood and *Pohutokawa* in eastern areas of the North Island; and in manuka in Marlborough. Pronounced wilting of understorey has been observed in drier hill slope forests in the eastern North Island and in Marlborough.

Reductions in sooty mould on trees has been observed, which is likely to affect dependent insect populations. In Taranaki, winds during early summer were the strongest on record and caused shredding of leaves on trees at exposed locations. Moss cushions and lichens have been torn from tree stems, resulting in reduced epiphyte cover.

Decreases in live vegetation and increases in the fraction of bare ground and litter production has been observed in snow tussock grasslands in the Awatea Valley, Marlborough. Severe wilting of all species of the invasive weed shrub *Hieracium* was also noted in this region. However, because of the plant's more aggressive root systems it is expected that it will recover more rapidly than other plants when rainfall resumes and that in this way, the El Niño conditions will enhance its further spread.

Dieback and tree death has been widely observed in shelterbelts, and in plantings for amenity and for soil erosion control (see also forestry section). Dieback has been observed in gorse and broom in Marlborough and in willow trees along stream banks where water flow has ceased.

Warmer summer temperatures are expected to result in heavy masting (flowering, fruiting and seeding) among some common New Zealand tree and herb species, including podocarps, beech (*Nothofagus*), southern rata and the large tussock grass *Chionochloa*. High summer temperatures in Fiordland during the 1997-98 summer, will induce heavy flowering and result in abundant seed production in the 1998-99 summer. A similar response has been recorded for *Nothofagus* in Fiordland and at Craigieburn Forest, and for southern rata forests in the Kokatahi Valley, Westland where flowering has been the most prolific for many years.

Complex ecological chain of impacts

The heavy masting (flowing, seeding) of native trees will assist breeding and population growth of birds in the next spring and summer, but will also benefit introduced rodents and their predators (mainly stoats, weasels and ferrets). Once rodent numbers are depleted by predators in late summer and autumn, the enlarged predator populations then attack native birds. For example, yellowhead numbers fall rapidly in years when there is a heavy beech mast, but their recovery of numbers in the following non-mast years is never sufficient, and so the bird population is gradually declining.

5. Prediction of ENSO and New Zealand climate

Given the large impact of climate variability in New Zealand, which has been estimated at over $1B annually, even small amounts of skill in climate prediction may easily repay the cost of the research and operational effort required.

Prediction methods

Climate predictions are concerned with how *anomalous* the climatic conditions of a coming month or season may be (e.g. colder, or wetter, than usual.) There are three basic approaches:

- Firstly, research on past events shows that El Niño and La Niña events tend to follow similar patterns of development and decay. After they have commenced, their evolution is therefore partly predictable. For example, when the El Niño event became established in mid-1997, scientists had high confidence it would stay in place and would have major impacts over the following twelve months.

- Secondly, research-based computer models can represent the main features of the ENSO phenomenon and can predict its future evolution to some extent. These models tend to focus on the tropical anomalies and on continental scales. To date they are unable to give useful predictions of New Zealand's specific climatic conditions.
- Thirdly, it is possible to use historical data to statistically link the local climatic anomalies with key indicators of ENSO, such as tropical ocean temperatures or the Southern Oscillation Index. For example, New Zealand is generally cooler when the Pacific tropical ocean temperatures are above average, but warmer when Indian Ocean temperatures are above average. Similar links can be made between major volcanic eruptions (e.g. Mount Pinatubo) and low New Zealand temperatures.

Weather forecasts cannot be extended to provide climate predictions, as beyond a week they have little useful accuracy, owing to the chaotic nature of the atmosphere. It is fundamentally impossible to predict individual weather systems ten days, a month or a season ahead. Climate forecasts can only predict the likelihood of particular climatic conditions in a future month or season, and not the weather events themselves.

Climate prediction is not always possible

Research has shown that about half of the variability of New Zealand's climate is potentially predictable. The remaining inherently unpredictable half arises from the random, chaotic nature of the atmosphere. So far, the scientific methods available to us today can only reach part of the available 50% predictability.

Unlike weather predictions, climate predictions are not universally available—in some regions and some seasons, the variations are essentially random and there is no scientific basis for making a climate forecast. Any "forecast" offered for these situations can be no more than unscientific guesswork.

To prepare climate predictions for New Zealand, a conference is convened each month among NIWA staff, with invited telephone participants from the Meteorological Service and Otago University, to review the recent month's weather, the global climate diagnostics (ocean temperatures, Southern Oscillation, tropical winds, etc), and the predictions of overseas computer models. New methods developed under Public Good Science Fund support are trialed and introduced as appropriate. A consensus on the ENSO situation and its likely evolution is sought, and participants then make use of this information independently in their own organisation's services.

Climate prediction depends on a system of international collaboration, especially to ensure the operation of Pacific Ocean monitoring systems and global climate prediction models. At present, this system is embryonic and fragile.

Locally, the situation is similar, in that there is no Government department with the mandate to ensure that authoritative, scientifically sound information is available to the public. Climate prediction services are undertaken only where organisational initiative, media interest, and minor commercial demand dictates.

Public services

Warnings of the 1997-98 El Niño event were made available publicly through press statements, some originating from overseas science agencies, and the following from NIWA.

- 6 April 1997: *La Niña Gone - Switch to El Niño Possible*. This provided an early warning that an El Niño might develop over the following months. It was issued earlier than those of most other countries.
- 22 June 1997: *Strong El Niño Developing*. The emergence of a strong event was confirmed and the implications for New Zealand were outlined.
- 21 October 1997: *Prudence not panic about El Niño is the way to approach this summer*. This encouraged the application of risk management approaches based on the climatic information, and noted that the El Niño was only part of the natural variability.
- 27 November 1997: *El Niño predicted to cause more frequent tropical cyclones in South Pacific*. Based on earlier research, this predicted more cyclones this season and a shift in the pattern toward the Cook Islands and French Polynesia (both predictions proved correct.) The release was issued to the media and to key agencies in the Pacific Islands.
- 8 November 1997: 1997 *Global Temperatures Highest Equal So Far*. This reported among other things the role of the El Niño in boosting global temperatures during 1997.
- 9 March 1998: *El Niño Gone by Winter*. The release reflected the emerging strong consensus of overseas centres that the El Niño was slowly fading away. No mention was made of the possibility of a La Niña developing later in the year, owing to the high uncertainty in that prediction.
- 25 Mar 1998: *Hot Nor'Westers Tumble Temperature Records*. This described the heatwave and how it was not typical of El Niños.

A number of local media reports on the El Niño made extensive use of scientist's inputs. More technical information was made available through NIWA's monthly climate summaries, its monthly *Climate Now* product and in response to commercial enquiries, and through the MetService's seasonal forecast products. Many users will have obtained global information directly from foreign sources through the Internet.

Geophysical, biological, and economic features confer some predictability

Groundwater reserves that have been depleted take time to recharge. Therefore they can be predicted to stay low until sufficient rainfall occurs. Supplies from the main aquifer in mid Canterbury have been sustained this season, but if the 1998 winter is drier than usual, the low water levels will cause further reductions in water availability next summer.

Changes in plant status can lead to "predictable" longer term consequences, such as rises and declines in animal populations (depending on predator-prey relationships), and possible expansions of weed and pest species (e.g. *Hieracium*). Similarly, marine species year-class populations may be predictable.

In agriculture, the current health status of farm animals and the availability of autumn feed can be used to predict future breeding success (especially lambing rates next spring). There are similar seasonal flow-on effects in tree fruit crops.

Reductions of income in drought-affected rural areas will reduce the capital resources of these areas and their industries, which will reduce their potential economic activity in the next year or two.

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6. Climate outlook for rest of 1998 - a fading event?

As at the middle of April 1998, strong warm episode (El Niño) conditions continue to prevail. Tropical Pacific sea surface temperatures are well above normal east of the date line, exceeding 3 °C above average in some eastern equatorial areas, though the anomalies are easing. The Indian Ocean is also anomalously warm.

Mid-April pressure anomalies at Darwin and Tahiti remain high, resulting in a Southern Oscillation Index around -3.0, which is very extreme. This important indicator shows that the atmospheric component of the event remains very strong.

Most overseas seasonal climate prediction models have been predicting that the El Niño event will slowly decline and may be over by the middle of the year. However, the continuing strength of the ENSO indicators does give cause to question whether the models are being too optimistic in their prediction of a prompt decline. Further ahead, the models are even less certain, but several are predicting that a La Niña event will emerge toward the end of 1998.

Irrespective of the rate of decline of the event, climatic anomalies will tend to continue for the next few months. Drier-than-normal conditions are expected over Indonesia, northern Australia, northern South America, and southern Africa. Wetter-than-normal conditions are expected over the central and eastern equatorial Pacific, along the coasts of Ecuador and northern Peru and over southeastern South America. Significant storm activity and rain are likely across California and the southern third of the United States possibly into April.

New Zealand will continue to be influenced by the El Niño during autumn (April to May) The typical autumn El Niño pattern is for cooler than average temperatures in the west of the South Island, and generally wetter conditions over much of New Zealand except for Auckland and northwards and the east of the North Island.

The currently warmer than normal ocean around New Zealand will also tend to keep North Island temperatures above average during the first half of autumn.

Recent research shows that autumn Indian Ocean temperatures have an influence on New Zealand winters (June to August). The central Indian Ocean is currently very warm, which suggests that winter is likely to have stronger than normal anticyclones over the North Island with drier conditions there and in the northeast of the South Island, along with above average temperatures in most places.

Beyond winter, the outlook depends on whether a La Niña develops or not. La Niña summers tend to be warmer than normal, particularly in the west of both Islands, and wetter in the north and east of the North island.

Interpret climate forecasts with caution

The evolution of the ENSO phenomenon is highly variable at this time of year and this is when the overseas computer models are least accurate. During the 1991-94 event, the models then available consistently predicted the end of the event each year, but this did not occur. For New Zealand, the predictions given above indicate the most probable of a range of possibilities, and they apply to the season as a whole. Individual months can be quite different from the seasonal mean. In some cases there is no scientific basis for forecasting a climate anomaly—e.g. for autumn rainfall in the north of the North Island.

7. Implications and conclusions

1. The El Niño clearly affects New Zealand's weather. It is typically associated with more frequent stronger winds from the south (in winter), southwest (spring and autumn) and west (summer), cooler conditions nationally, more rain in western regions and drought in eastern regions. However, other natural climatic variations are large and can swamp this simple picture of El Niño influence.
2. The typical El Niño pattern has been generally present in the current event, and large areas have been affected by drought. The main exception has been the very warm summer, which culminated in the atypical, exceptionally warm month of February, when the prevailing westerlies took on a northerly component.
3. Climatic impacts reported recently include pasture losses, agricultural production decreases, tree deaths in native forests and plantations, and depleted water resources. Some impacts will have consequential effects next year. The cost of the drought to farm gate returns alone this season and next has been estimated by MAF at $425M. Most of this can be attributed to the El Niño event.
4. There is a large body of scientific knowledge about how plants, animals, ecosystems, and industries react to climatic fluctuations. Experts and decision-makers in these fields can apply historical climatic information and predictions to improve planning, production, land use sustainability, and the management of risk.
5. Most of our knowledge about the El Niño, and about to how handle its effects, has been developed through scientific research. Current research, for example, includes the development of climate prediction techniques and drought-resistant pasture species.
6. During the present event, sector groups, farmers and other decision-makers have been forewarned of the El Niño and some have used this information to recommend and implement a variety of management strategies to reduce risk and possible losses.
7. There is a growing scientific basis for observing and predicting the global climate and the New Zealand climate, but at the same time, there are many occasions when there is no scientific basis for predictions. Users face a range of sometimes conflicting predictions, and in some cases the predictions on offer do not have a valid scientific basis.
8. The organisational systems and linkages required to generate authoritative prediction information and to successfully apply it in users' fields remain undeveloped. In addition, the monitoring and assessment of climatic impacts is *ad hoc*. There is a new opportunity to fuse the various sciences, and the research and user communities, to more effectively deal with climatic impacts, especially drought.
9. The current El Niño event remains strong. Current indications are that it may slowly decline over the next few months and perhaps disappear by the winter. However, caution is advisable as there is considerable uncertainty in climate predictions.
10. The relationship between El Niño and climate change remains unclear. However, there is a practical link, since the El Niño and its climate impacts provide a training ground for dealing with future variability and impacts under climate change.
11. The 1997-98 El Niño event provides a valuable opportunity, both globally and in New Zealand, to gather information on how decision-makers have responded to climatic stresses, and on what specific and generic adaptations were developed or applied.

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(Note: The following links, which were valid in April 1998, now take you to copies of their content that have been archived on web.archive.org.)

http://nic.fb4.noaa.gov:80/products/analysis_monitoring/ensostuff/index.html

http://nic.fb4.noaa.gov:80/products/analysis_monitoring/enso_advisory/index.html

http://www.ogp.noaa.gov/enso/

http://www.wmo.ch/nino/updat.html

http://iri.ucsd.edu/hot_nino/sst_fcst/

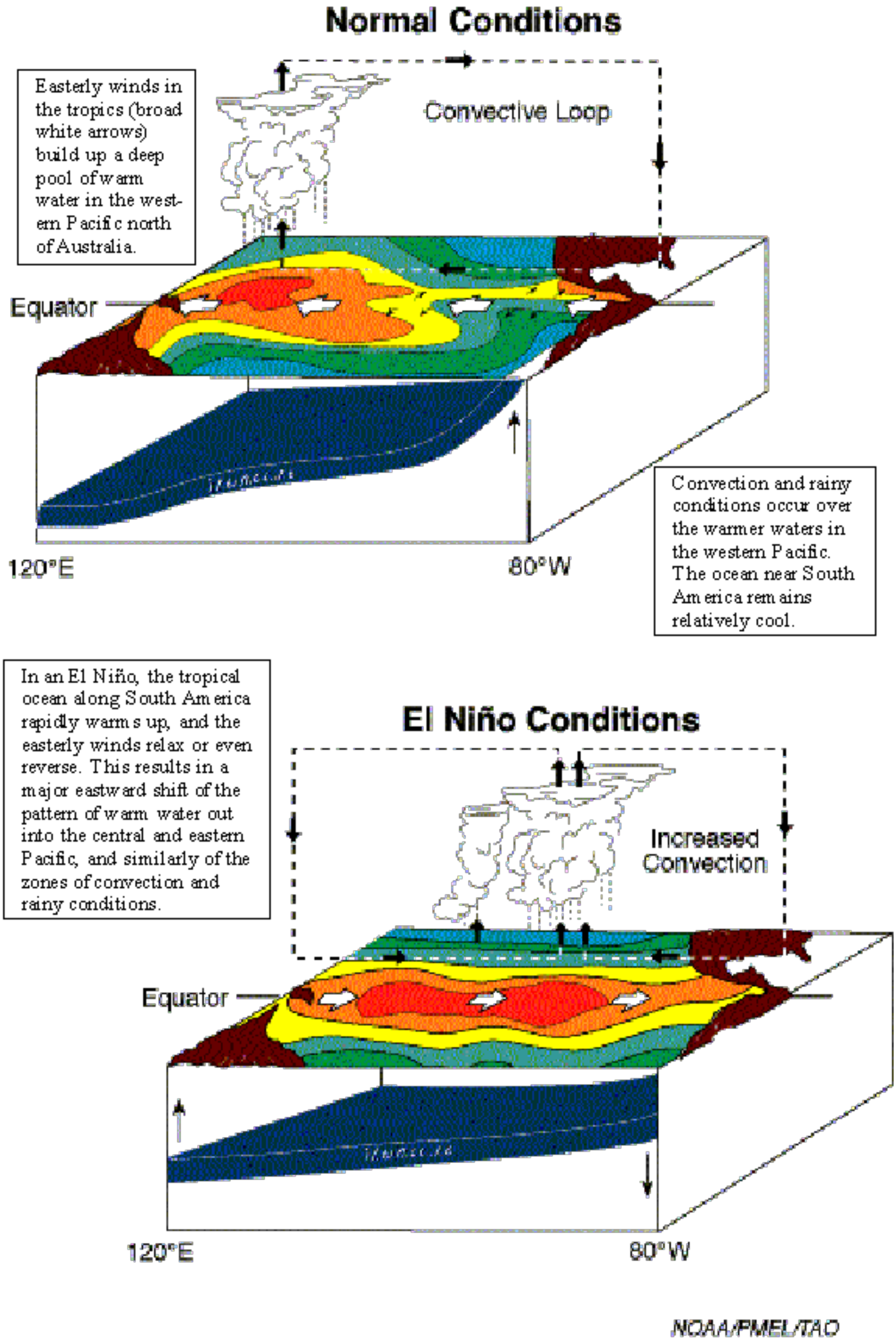
http://www.pmel.noaa.gov/toga-tao/gif/daily/sst_wind_anom_inline.gif

http://www.bom.gov.au/climate/current/meansst.shtml

http://www.wmo.ch

http://aqdb.niwa.cri.nz/ClimateNow/

Annex 1: Schematic of El Niño Southern Oscillation (ENSO) Phenomenon



Annex 2: Summary of weather and climate anomalies July 1997-March 1998

July. Marked El Niño characteristics were apparent, with more frequent south westerlies, extremely low rainfall in the southwest of the North Island, and very dry conditions in Canterbury. It was very sunny overall, with less wind, though rather cold and wet in the southwest of the South Island, with freezing fog in Central Otago during the first 9 days.

August. Very wet conditions continued in the southwest of the country, with low rainfall persisting in Canterbury (for the 6th month running) and Manawatu (for the 5th month running). Frequent westerlies and southwesterlies, with significant snowstorms in the south and east of the South Island.

September. Low rainfall continued in south Canterbury, with extremely low rainfall on the West Coast and in the Southern Lakes. However, this was due to easterlies being more prevalent than usual, rather than the typical El Niño type of anomaly.

October. El Niño southwesterlies resumed, with record high sunshine in Nelson, and extremely sunny conditions in Gisborne. It was very dry in the north of the South Island, and Central Otago, but wet in the southern half of the North Island.

November. Windy, with notable El Niño characteristics; air flows from the southwest were the strongest on record for any November. Extremely sunny conditions continued in the north of the South Island. It was very wet and cold in the south and west of the South Island, but very dry around Cook Strait, and in eastern regions. Near, or record high, extreme maximum November temperatures occurred in the north and east of the South Island.

December. Persistent wind, with westerly air flows the second strongest on record for December. Extremely dry, and warm in the east of the North Island. Dry also in western Bay of Plenty, Wellington, Nelson, and Marlborough. High fire risk occurred in many areas, and agricultural drought became established in many eastern regions, from Gisborne to Canterbury, including Nelson. It was very cold, wet, and unsettled in the south and west of the South Island, as well as Taranaki. Unseasonable snowfall occurred in the southwest of the South Island on 2 December.

January. Westerlies continued, with drought conditions intensifying and spreading. Extremely dry in the north of the North Island and east of the South Island, especially Canterbury. Sunny, warm weather in the east, but cool and cloudy in the west of the North Island. Unseasonable snow in the high-country, Otago/Southland, and on Mt Taranaki on 9 January.

February. Warmest month for New Zealand since reliable temperature records began in 1855. National mean temperature was 2.7 °C above average. Dry conditions continued in eastern regions, but it was very wet in the south and west of the South Island. North-westerlies were more frequent than usual, with unusually high temperatures, especially in the east. This is not typical of an El Niño. Rain gave relief in some areas at the end of the month, but drought remained serious in parts of Gisborne, Hawke's Bay, Marlborough, and north and central Canterbury. The summer ended as one of the driest on record in north Canterbury and Hawke's Bay.

March. Classic El Niño conditions prevailed. Westerlies resumed, especially in the south, and extremely dry conditions and serious drought continued in Hawke's Bay. It was also very dry in the lower North Island. Rainfall was near average in parts of Marlborough and Canterbury; enough in some areas to provide temporary relief from the drought. Rather wet conditions prevailed in the south and west of the South Island. It continued to be unusually warm, especially in the north and east. All-time extreme high maximum temperatures occurred in the east of the South Island on the 24th. Severe gales buffeted central and southern New Zealand as ex-tropical cyclone Yali tracked across the lower South Island on 29 March.

April (to mid-month). Strong westerlies occurred, with above average rainfall in the southwest of the South Island. Rainfall was low in Wairarapa and Wellington, and very low in Nelson and Canterbury. Very warm conditions continued in the North Island, as well as in Canterbury.

Annex 3: MAF estimates as at 21 April 1998 of current and potential farm gate losses in 1997/98 and 1998/99 years attributable to the El Niño

Decline in Production Current Year (1997/98)

1. Sheep and Beef	
Lower Lamb Slaughter Weights	
Number of lambs born in 1998.	$38.5 million
Early anticipated number of lambs to slaughter.	$26.8 million
Now anticipated number of lambs to slaughter (due to drought).	$27.5 million
45% of These Lambs Anticipated to Now be Killed at Slaughter	
Weights 1.2 kg less than anticipated @ $2.30 /kg.	$34 million
Lighter Ewes to the Works	
1.71 million ewes @ $5.00 less.	$10.5 million
Lighter Cattle Slaughter Weights	
Down 15 kg on average for 680,000 cattle @ $2.00 /kg.	$20 million
Lower Wool Weights	
46 M x 45% = 20.7 M sheep with 0.3 kg less wool @ $2.60 /kg.	$16 million
Extra Cartage of Feed, Grazing and Water (net)	$11 million
Regrassing, extra nitrogen etc.	$10 million
Total costs Sheep and Beef this year	**$101.5 million**
2. Dairying	
A reduction of 20,000 tonnes of milk solids on the earlier prediction of 930,000 tonnes @ $3.40 /kgMS.	$68 million
3. Deer	
Lower fawn growth rates lighter meat and velvet yields.	$1.5 million
4. Arable	
The impact is felt this year in the form of lower yields than anticipated. Estimates include grain and process crops grown in both Islands.	$45 million
5. Horticulture	
Mostly in the pipfruit sector, with sunburn, lack of fruit colour and lenticell blotch and size problems -very significant in Hawke's Bay. But vineyards report good prospects.	$40 million
TOTAL COST 1997/1998	**$256 million**

Decline in Production Next Year (1998/99)

1. **Sheep and Beef**

10% Drop in Lambing in drought affected areas	
1,900,000 lambs @ $40	$76 million
Herd and Flock rebuilding	
(Net of sales during 1997/1998.)	$40 million
Lower Wool Weights	
20.7 M sheep @ 0.3 kg, @ $2.60 /kg.	$16 million
Teeth Wear shortening productive life	$10million
Replenishment of Feed Costs	
(Opportunity costs.)	$5 million

2. **Other**

Dairying	
Cows should be in calf satisfactorily. But next spring may not calve down in such good condition, thus affecting production.	$20 million
Deer	
Lower fawning percentages.	$2 million
Arable and Horticulture	
No lasting effects.	

TOTAL COST 1998/1999	**$169 million**
TOTAL COST 1997/1998 and 1998/1999	**$425 million**

[Note, June 2026: Reserve Bank inflation data shows that these costs need to be doubled (x1.98) to convert to 2026 dollars.]

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