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AN ASSESSMENT OF CRITICAL CLIMATIC PERIODS AND POSSIBLE COLD INJURIES ASSOCIATED WITH PREHISTORIC LIFE IN MURIHIKU

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Introduction

The marked regional variation in climate throughout New Zealand is clearly evident. From the cold alpine regions of both the central North and South Islands to the humid, warm temperatures of northern North Island, it is clear that the initial Polynesian settlers to Aotearoa/New Zealand would have had a selection of environments in which to settle. Since the southern coast is regularly exposed to strong, cold south/south westerly winds and cool weather systems originating in the Antarctic, rainfall is frequent and the waters of Foveaux Strait are cold and rough. For the early Maori, these elements would have been unfamiliar and difficult to contend with. Consequently, climatic parameters may be outlined for a critical period during the year where a combination of climatic elements would have made life in Murihiku demanding and uncomfortable, possibly even resulting in physical injury. Murihiku is the Maori name for the southern area of the South Island of New Zealand. Sutton and Marshall (1980) identified Murihiku as lying below 44 degrees South and includes Stewart Island (Rakiura) and Ruapuke Island (Figure 1.)

An overview of the Murihiku and Pacific temperature ranges

New Zealand exhibits considerable regional variation within a temperate climate with the average air temperature steadily decreasing from north to south. The initial Murihiku settlers may also have found it difficult to cope with the South's more pronounced temperature extremes. This is illustrated by data recorded between 1905 to 1970 that shows the highest maximum-minimum temperature range recorded at Invercargill airport was 40.2 deg. Celsius (maximum temperature 32.2, minimum -8.0). In comparison, data collected between 1930

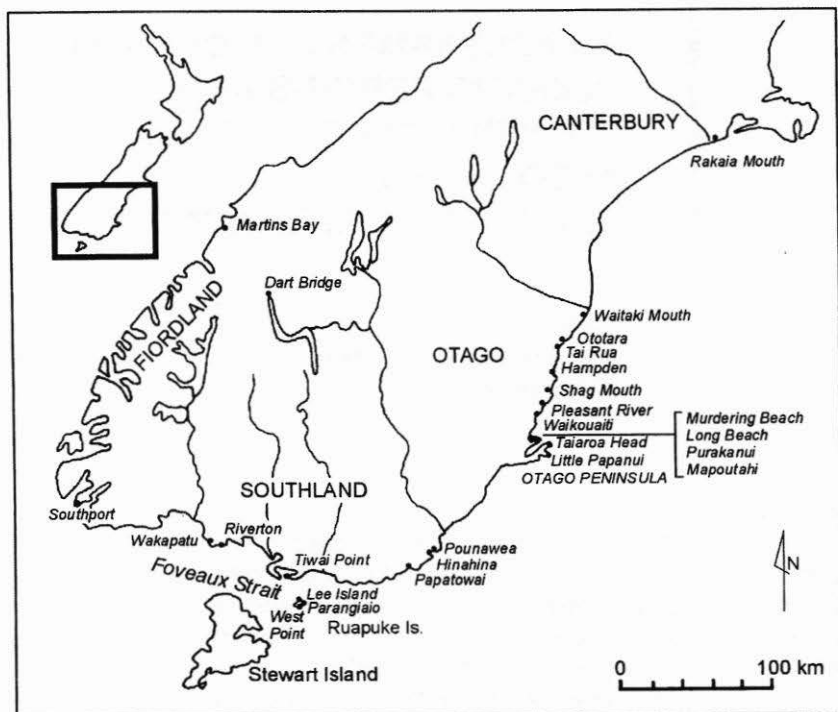


Figure 1. Map of Murihiku showing a number of early Maori settlement sites. Source: Anderson 1988: 94).

to 1970 on Apia, Western Samoa revealed a temperature range of only 16.2 deg. (maximum temperature 33.8, minimum 17.6) (NZ Met. Service Summary of Climatological Observations 1973).

The average daily temperatures recorded at various locations throughout the Pacific also highlight this large discrepancy between Murihiku and Pacific temperature ranges. For the period of 1941 to 1970, the island of Aitutaki in the Cook Islands recorded an annual average daily temperature of 25.6 deg., Rarotonga airport recorded 23.8 deg. and Asau, Western Samoa, 26.7 deg. (NZ Met. Service Summary of Climatological Observations 1973: 73-74). These warm temperatures seem even more pronounced when you consider that the annual average daily temperature from 1941-1970 recorded at the Invercargill airport was only 9.6 deg. (New Zealand Met. Service Temperature Normals 1978: 14). Of course, variation in temperature over seasons, regions and different years should be considered. However, these figures give a good general

indication of the marked drop in temperatures that occur between Pacific Islands and southern New Zealand.

Data for the Murihiku climate was taken at Invercargill airport since this is where a primary temperature station for the coastal southern area is situated. Invercargill airport is located about 10 minutes out of the city and is in a flat, open area relatively close to the coast. Consequently, weather conditions recorded at this station may, for the purposes of this exercise, be regarded as generally representative of the southern coastal climate. Since the majority of early Murihiku settlements were situated on the coast (Purdue 2000: 44-86), data collected from the Invercargill airport was given priority.

Apart from significantly cooler temperatures, many other prevailing southern weather conditions would have contributed to uncomfortable living environments. The conditions around the southern coast of the South Island are predictably coldest in the winter months of June, July and August. In accordance with the exposed nature of the southern coast, the land around Foveaux Strait is frequently buffeted with prevalently cold west/south west winds and frequent rainfall - on average Southland experiences more than 200 days per year with rain (NZ Met. Service Climate of NZ 1986: 3). The combination of frequent rainfall with even a light west/south westerly wind would have had a considerable chilling effect on exposed skin. Houghton supports this, claiming that the crucial influence of wind on body cooling occurs at low velocities (Houghton 1996: 68, 85) and that wind plus wetness doubles the rate of heat loss (1996: 64).

Snow, hail and frost also occur in Murihiku and would have been unfamiliar and uncomfortable to the early Polynesian settlers. Even though snow is less common than rain, the combination of freezing temperatures, snow and hail would have posed a significant threat to any unprepared human. Sea temperatures in Foveaux Strait reach between 10 to 13 degrees centigrade and 8 to 10 degrees at the ocean floor (Shaw 1998). The regular contact with cold water that was necessitated by the subsistence strategies of the southern Maori would have increased their chances of suffering from some form of cold injury, particularly during the critical winter period.

Parameters for a critical climatic period

A critical period is the time during the year where a combination of climatic conditions occurs that is sufficiently severe to possibly cause physical injury to the inhabitants of the area. There are several factors involved in the development of a critical period. They include the effect of wind chill on human temperature

perception (also known as the equivalent wind chill temperature, or EWCT) and the continued presence of ground frost, rain, wind, hail and snow. We know that Murihiku experiences cooler air temperatures than many other parts of New Zealand and when wind chill is taken into account, it becomes considerably colder. It is possible to calculate the EWCT using a set formula developed in 1945 by Antarctic explorer Paul Siple and his colleague Charles Passell (Oliver and Fairbridge 1987: 928). The EWCT was used as the basis for calculations and conclusions when establishing temperature parameters for a critical period.

Using information from climatological readings collected at the Invercargill airport, it was concluded that a critical period occurs when the equivalent wind chill temperature falls below 5 deg. C. for a sustained period, or over half of the number of days in the month. Incorporating Siple and Passell's wind chill formula with data from a standardised cumulative frequency table of mean daily temperatures taken at the Invercargill airport from the period of June 1948 to December 1974 (NZ Met. Service Temperature Frequencies 1977: 22), and including mean monthly wind speeds (NZ. Met. Service Climate and Weather of Southland 1984: 12) the number of days per month that the wind chill temperature dropped below 5 deg. C. was calculated (Figure 2).

Clearly, a critical period of the year fell between the months of April to September. This equates to six months of the year where the equivalent wind chill temperature reached 5 deg. or below for a portion of the 24 hour period and occurring at least half of the total number of days of the month. The most critical months are May through to September. During July, in the heart of the southern winter, the frequency of an EWCT of less than 5 deg. rises to 97.9% on the exposed southern coast (Table 1). In association with this phenomenon, the greatest occurrence of ground frost appears during the winter period of June, July and August, occurring with a frequency of 50-65% of the total number of nights during each month. Hail also peaks at around this time, with an 8-12% likelihood of falling during each month (NZ Met. Service Summary of Climatological Observations 1973: 73).

These sustained freezing conditions, low temperatures, hail showers, strong westerly winds, regular rain and exposure to very cold sea temperatures would have provided a period of six months of the year where the conditions were sufficiently critical to cause some form of cold injury. Although the data used to determine these figures was averaged, this exercise gives us a good insight into what conditions the southern Maori may have been exposed to.

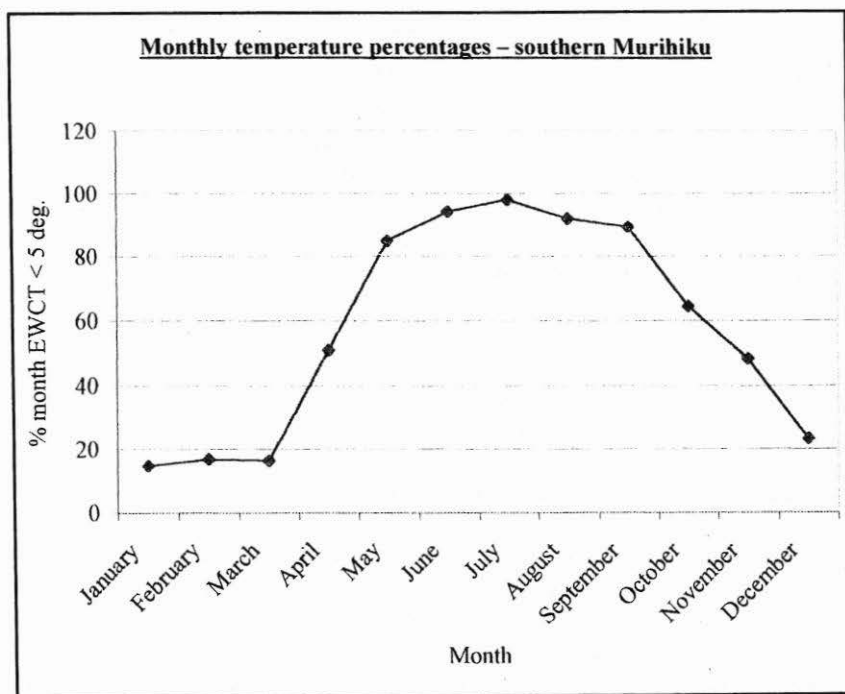


Figure 2. Percentage of each month where EWCT is less than 5 degrees. Based on information from cumulative data of mean daily temperature taken at Invercargill airport and mean monthly wind speeds along the southern coast.

The suitability of clothing and alternative methods of negating the effects of the cold

The clothing of the early southern Maori would have had to have been sufficiently warm, wind and waterproof to provide adequate protection from the biting winds, cool temperatures and frequent rain during the critical period. Archaeologically, there is little evidence of their clothing as the organic fibres often decompose in less than optimal conditions. Consequently, the bulk of the evidence comes from ethnographic sources. A key question is: what types of apparel did the southern Maori have, and how effective would it have been in protecting them from the elements?

The principal item of clothing was the mat or cloak, also known as the *kakahu*. This was usually made from woven flax, although other materials and additional

accessories such as dog skin and feathers were part of the manufacture. The mat was full length, worn around the shoulders and fastened with a pin (Thomson 1859: 204-205) (see Figures 3 and 4). The garments provided warmth by trapping warmed air between the torso and the cloak. An essential type of cloak for the southern people was the rain cloak (*Pokeka* or *kahu-koka*) (Buck 1949: 160-161; Mead 1969: 63-64; Leach 1987: 20; Anderson 1994: 47-48). The *kakahu* could be brought closer to the body with belts, and the *pokeka* could then be placed over the top. Both men and women also wore a type of girdle and apron or kilt around the waist (Mead 1965: 15-158). These garments were made of dried flax and were designed to preserve modesty by covering the loins, rather than as any inherent heat-preservation measure since the legs were left bare. It is clear that these garments afforded little protection for the legs and hands, which were left relatively exposed. The main insulation came from the trapping of warm air around the torso by the large encompassing cloaks. There were few items of clothing that protected the body in its entirety from the chilling wind, wetness and frost that was part of the Murihiku environment.

Evidence, both archaeological and ethno-historical, is scarce for the utilisation of leggings, gloves, hats and shoes. Generally, the prehistoric Maori left their legs and feet uncovered. Thomson (1859) states that in the south, sometimes sandals made from flax or cabbage (*ti*) tree leaves were worn, however, these were generally used to protect the feet when walking over rough ground rather than as a primary method of keeping the feet warm (Anderson 1994: 50). Calf-length leggings made from *tikumumu* leaves, *whitau*, or *patiti* (silver tussock) were worn when engaging in warfare, or when passing through rough terrain (Mead 1965; 1969: 122-123; Tregear 1973; Anderson 1994: 52). They may have inadvertently provided some thermal insulation for the lower leg, although this was not the purpose for which they were intended.

Nowhere has there been any record of the southern Maori using any method of protecting the hands from the cold. No evidence has been found in archaeological sites and scholars who have studied clothing do not mention the presence of gloves prior to European contact (Mead 1965, 1969; Buck 1949). Likewise, it is uncertain whether any measures were taken to protect the head. The head is an area from where up to 30-40% of body heat can be lost (McArdle, Katch and Katch 1996: 505; Lloyd 1986). The nose and ears are also particularly vulnerable to the elements. No archaeological evidence of prehistoric hats has been found, and Beattie's informants claimed that according to their knowledge, there was indeed no hat in the prehistoric wardrobe. Widows wore a feather mourning cap called a *potae*, however, any tendency for early post-contact



Figure 3. Parkinson: "A New Zealand Warrior in his Proper Dress, & completely Armed, According to their Manner" (Morrell 1958: 96).

Maori to wear hats was ascribed to European influence only (Anderson 1994: 50-51).

The application of mutton-bird fat directly onto the skin was a practice that while it caused skin irritations such as eczema, was probably used to keep contact between wind, water and skin to a minimum (Shortland 1851: 226). The layer of grease would also have prevented the rain from forming a film on the skin and possibly from lowering the body temperature as it evaporated. Oil applied to the hair (which was also a common practice in Polynesia and Tasmania) may have waterproofed it quite effectively, thus preserving scalp temperature and reducing the necessity of any substantial form of head covering

(Anderson 1994: 63). However, the extent to which the practice of applying ointments/substances to the skin prevented heat loss has recently been tested. Results tended to show a minimal level of thermal insulation, suggesting negligible protection against the cold (Lehmuskallio and Anttonen 1999; Lehmuskallio 1999). Evidently, there is some uncertainty surrounding the effectiveness of this procedure.

Clearly, the early southern Maori would have had bare skin exposed to the elements over all seasons. A.S. Thomson notes that there was little change in attire from summer to winter (Thomson 1859: 205). During the bitterly cold winter months, the extremities would still have been exposed to the elements and considering the length of time that the equivalent wind chill temperatures would reach below 5 deg. in Murihiku and the preponderance of rain, the unprotected extremities would have been vulnerable to problems associated with cold exposure.

Cold injuries most likely to have been endured, and associated with exposure to water and/or low temperatures

A number of well-known injuries are caused by exposure to intensely cold weather over a prolonged period. Even though they are often not life threatening,

they can be extremely painful and debilitating, especially to a people whose lifestyle was very active. Several ailments that may have affected the southern Maori are frostbite, chilblains and non-freezing cold injury (otherwise known as trench-foot). The appearance of New Zealand 'leprosy' as a possible cold injury will also be discussed. It should not be assumed that southern Maori were as susceptible to cold as contemporary populations who rely on technology as a buffer against climatic extremes. Biological adaptation to the cold can take various forms, including increased metabolic rate, lowered skin temperature, or even hypothermia (Bittel 1992) and there is evidence that pre-European Maori and Moriori may have had reduced skin sensitivity to the cold (Visser and Diaz



Figure 4. Augustus Earle: "Two Warriors"
(McCormick 1966: plate 14)

1999). However, these adaptations serve only to lower the threshold at which injury occurs or delay the onset, rather than prevent it.

Frostbite

Frostbite is particularly painful and primarily affects the appendages, mainly the hands, feet, ears and nose. Frostbite is a localised freezing cold injury that occurs when the affected limbs are exposed to temperatures 0 deg. or below

for a prolonged period (Wilkerson, Hayward and Bangs 1986: 84; Lloyd 1986: 84). The hands and feet are prime candidates for frostbite, as they do not contain large heat producing muscles and are a considerable distance away from the major sites of heat generation. As a result, the blood supply to the hands and feet is the first to be reduced when the body needs to conserve heat (Wilkerson, Hayward and Bangs 1986: 84; Lloyd 1986: 84). In addition, the ears and nose are prone to frostbite since the tissue here is thin, easily chilled and often exposed directly to the wind.

Symptoms of frostbite include swelling and pain. The area is usually pale and as the tissue freezes, sensation is lost and the extremity becomes firm to the touch. In severe cases, the area becomes purple and then black as tissue necrosis ensues (Wilkerson, Hayward and Bangs 1986: 89). These extreme cases occur when temperatures are continually well below freezing, however, milder forms still create pain and discomfort for the sufferer.

Chilblains

The chilblain is a milder form of localised cold injury and would probably have been more prevalent among the southern Maori than frostbite. While less severe than frostbite, the chilblain can be extremely painful. Chilblains are most commonly found on the fingers and toes. They are caused by repeated exposure of bare skin to wet, windy conditions and temperatures ranging from 15.5 deg. to near freezing. Inadequate clothing is often an important causal factor (Wilkerson, Hayward and Bangs 1986: 101; Lloyd 1986: 84). Symptoms include swelling accompanied by redness and warm sensations. The area becomes tender, with itchiness, drying, blistering and cracking occurring (Wilkerson, Hayward and Bangs 1986: 101). Unlike frostbite, the injury is purely superficial.

Given the fact that the subsistence strategies of the Murihiku Maori revolved largely around the sea and its resources, continual exposure to cold water would have been a realistic part of their daily activity. For the men involved in fishing and voyaging, and for the women collecting shellfish, the repeated and prolonged immersion in water would have served to cause and aggravate this condition.

Trench-foot

A similar ailment to the chilblain is trench foot, also known as non-freezing cold injury (NFCI) or immersion injury. NFCI is more severe than chilblains, and the causative factors in this complaint are once again prolonged exposure to wet conditions and cold temperatures above 0 deg. (Lloyd 1986: 89).

Trench foot is caused by a reduction of circulation to the submerged extremities as a heat saving mechanism. The cold water in contact with the feet extracts much of the remaining heat from the tissue and causes further vasoconstriction. Symptoms include pain, prickly/tingling sensations, redness, swelling and blisters (Wilkerson, Hayward and Bangs 1986: 98; Lloyd 1986: 90).

The best way to prevent NFCI is to limit the time that the person is exposed to the hazardous environment, ensure that there is adequate hydration and that the feet are kept as dry, warm and abrasion free as possible (Lloyd 1986: 91). This may have been difficult to achieve in southern New Zealand, where the majority of the day would have been spent outside engaging in various activities associated with food collection and preparation, textile and tool manufacture, travel, or general relaxation. Even during the winter months when staying indoors and living off preserved food stores were the main activities, it would be hard to keep the feet dry and warm when venturing outside.

'Leprosy'

While it is clear that the ailments mentioned above are a direct result of exposure to the elements, 'leprosy' has a place in New Zealand's prehistoric oral history and is surrounded by uncertainty and controversy. This disease may be mentioned in the context of this paper due to the fact that some symptoms of New Zealand 'leprosy' are similar to those exhibited by cold injuries discussed so far. The question then arises of whether there is sufficient evidence to argue that 'leprosy' may actually have been a severe form of cold-related affliction, rather than a separate and undoubtedly unpleasant disease.

A.S. Thomson, an English-born army doctor, used the medical name *Lepra gangraenosa* for the condition. He documented a clinical description of the symptoms (Gluckman 1976: 200-202). These included swelling, itchiness, hot sensations, dryness and blistering culminating in the death of tissue and the dislocation of affected extremities. Thomson also stated that "the healthy toes and fingers are dry and shining, and scabby like; they are as warm as the other parts of the body, but from being kept bent, the skin and tendons appear to contract, and the fingers are stiff" (Gluckman 1976: 200-202). These symptoms exhibit important similarities to the symptoms of the aforementioned cold injuries and the fact that the joints die and digits fall off suggests some cessation of circulation, an important factor in the development of all forms of cold injury.

Similarly, Boulton describes an Otago woman who was believed to have been infected with 'leprosy':

"At Otakou I saw, for the first time, the effect of a singular but dreadful disease, called Tuhawaiki, by which a woman had lost her hands and toes as though they had been frostbitten. She was not more than 30 years of age and appeared to be at present healthy. The mutilated stumps had healed, but the limbs had a shrivelled appearance, and were of a darker colour than other parts of her body."

(Shortland 1851:13-14)

Could this description of so-called 'leprosy' actually be describing a cold-induced affliction? Were the accounts of shrivelled, black extremities actually describing a gangrenous condition caused by vasoconstriction? It is difficult to definitively prove the presence of 'leprosy' in New Zealand. Houghton is not convinced that leprosy as we understand it was present in New Zealand since there appears to have been no skeletal evidence (in the form of distinctly eroded bones) found in prehistoric Maori remains, or indeed, anywhere in Remote

Oceania (Houghton 1980: 132; 1996: 216). Houghton also claims that various skin disorders may also mimic some of the features of leprosy (Houghton 1996: 216). Conversely, the lack of physical evidence may be attributed to the practice of exiling a sufferer, thus denying them a proper burial.

In further support of the cold injury theory, the accounts of New Zealand 'leprosy' describe symptoms similar to those associated with frostbite and other NFCIs, and recorded sightings of 'leprosy' have tended to occur in interior and coastal regions where temperatures can become very cold. These include Bluff, Stewart Island, Otago, Taupo, Wanganui and Rotorua (Buck 1910: Gluckman 1976: 199; Starke 1986: 63; Anderson 1994: 84). In addition, as previously discussed, there appear to be no noted prehistoric methods of protecting the hands and feet from the elements.

Indeed, cases of so-called 'leprosy' were documented amongst 19th century Chinese miners and immigrants in Central Otago. In 1871, doctors cited one case of a man with 'leprosy' who had died at Lawrence. There were two other 'leprosy' cases at Lawrence in 1872 and 1878. Two more 'lepers' were diagnosed in 1879 and were placed together in a 'leper house' in Lawrence (Ng 1993: 311). A number of other Chinese said to be suffering from 'leprosy' were also documented in the Central Otago area around this time. In 1880 at Grey River on the West Coast, a case of 'leprosy' in a Chinese man was identified. 'Leprosy' was regarded by Otago European doctors as non-contagious and indeed, Ng stated that no one in New Zealand was known to have caught the disease from a Chinese sufferer (Ng 1993: 311). Petchey (1995, 1998) refers to local residents of Murphy's Flat, Kathleen Aitken, Neil Roy and Jim Dunkley when claiming that there is some doubt that local Chinese 'leper' Hui Shing Tsok actually suffered from 'leprosy' as such (Petchey 1995: 58).

Winters were harsh and extremely cold in the Central Otago goldfields, and the Chinese settlers who lived there were often exposed to climatic conditions that would have been deleterious to their health. Miners in particular often had wet extremities as they worked in stream beds and with hydraulic sluices. It is not beyond belief that like some of the early southern Maori, these unfortunate victims of so-called 'leprosy' may actually have been suffering from some form of extreme cold exposure. Since there appears to be little evidence directly and unconditionally identifying the affliction discussed here as leprosy and since some aspects of the disease are symptomatic with cold injury, exposure to the cold cannot be ruled out as a contributing factor.

Other minor conditions that are likely to have occurred regularly and which would have lowered the quality of life are coughs, bronchial infections and conjunctivitis (aggravated by the smoky atmosphere of indoor fires) (Buck 1910: 71), tuberculosis and lung disease (Thomson 1859: 211-212), rheumatic disorders (Thomson 1859: 214), earache (Anderson 1994: 83) and skin diseases such as ringworm, scabies and eczema (caused by the application of mutton bird fat onto the skin, the excessive consumption of this fat and the tendency to wear dirty mats) (Gluckman 1976: 140; Shortland 1851: 226; Thomson 1859: 215).

Conclusions

It is impossible to prove that the early southern Maori definitely suffered trauma directly related to cold exposure, as these injuries do not leave skeletal evidence. However, given the fact there appears to be a critical climatic period from April to September where the EWCT falls below 5 deg., and since there was apparently no intensive method of protecting the extremities, it seems reasonable to assume that there was an increased chance of suffering from conditions such as frostbite, chilblains and trench foot (NFCI). Respiratory and ocular complaints would most likely have been common and an indirect result of life in a cold climate. If these ailments were severe enough, they would have succeeded in debilitating the victim to the extent that life would become very uncomfortable and restrictive.

Several cases of a condition called 'leprosy' have been recorded in New Zealand, not only in the Maori, but in Chinese miners as well. Nonetheless, as there is no skeletal evidence (as documented by Houghton 1980; 1996) and the symptoms are similar to those exhibited by the cold injuries discussed, the possibility that this may be a severe form of cold injury should be considered.

It seems likely that the health and well being of the southern Maori may have been adversely affected by the southern climate, particularly during the critical period. All of the previously mentioned ailments are painful and can affect the mobility of the hands and feet. For the southern Maori, who were seasonally very mobile and subsisted on primarily a hunter/gatherer economy, activity and mobility were a large part of their everyday lifestyle. Any ailment that would inhibit a person's mobility would therefore be detrimental to the quality of that person's life.

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