EVIDENCE OF CLIMATIC CHANGE FROM THE VEGETATION OF THE NORTH ISLAND

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Since Holloway's paper (1954) on changes in Southland forests, attention has naturally been directed towards the possibility of corresponding evidence in the North Island that might prove or disprove his thesis. Changes are conspicuous and widespread in various types of vegetation; their interpretation however has only produced very tentative evidence in support.

Under these circumstances my only course is to consider the various changes observed in North Island forests and review some of the possible causes.

One advantage of working in the central North Island is that over at least the last half of the post-glacial period there is a time scale, provided by a series of volcanic eruptions at intervals of 1000-2000 years whose ash is preserved in peat bogs.

The evidence in the peat lies outside my terms of reference, but the last of the eruptions, the Taupo shower, destroyed the preceding vegetation over a radius of about 30 miles. The surface of this shower still carries a recognizably distinct vegetation including most of the remaining podocarp-dominant forest in the island. Where beech* forest is present, as in the Kaimanawa and Kaweka ranges, the unusually high timber lines and vigour of growth are also distinctive. These features make the Taupo eruption an obvious datum line for placing the events of the past 2000 years.

Podocarp-dominant forest was not, however, confined to volcanic country. At least one other extensive forest existed up to the time of European settlement, the 40-Mile, or 70-Mile, Bush on late Pleistocene gravels and more recent silts along the eastern foot of the Ruahine Ranges. It has been so completely destroyed and so little has been recorded by early settlers that there is little point in making what can only be assumptions about its origin, beyond that podocarp forest could occur on other than volcanic soils until settlement destroyed it.

Recently podocarps have failed to maintain themselves in the surviving lowland forest except under special conditions where they may regenerate vigorously as in kahikatea semi-swamp forest. The immediate question is how far replacement of podocarps is a continuous process or whether there are any discontinuities sufficient to mark a change in the conditions over the period since the re-establishment of forest on the Taupo ash.

That rimu regeneration should be also inadequate over the whole range of both islands to as far north as 36° S. rules out temperature and throws doubt on climate as the deciding factor for this species.

In montane forest *Libocedrus bidwillii* and *Dacrydium biforme* show some features that match those of lowland forests. They have a similar life spon (600+ years) and show comparable evidence of being replaced (in their case by a subalpine scrub formation), and they also show an ability to regenerate under limited favourable conditions. They differ, however, in that both are almost completely absent from the area of the Taupo ash though distributed north and south of it. What is of interest in the present context is the sequence of their replacement from south to north on the axis ranges, particularly along the Ruahine Range which bridges the wide climatic and vegetational interval between Cook Strait (Tararua) and the central North Island (Kaweka-Kaimanawa). It may be regarded as a 60-mile-long transition between them and the best place in which to look for evidence of change.

Libocedrus is absent from the Tararua Range but *Dacrydium* appears sporadically towards the northern end, where its range is vertically contracted upwards possibly due to a change in climate (Wardle, 1962). North of the Manawatu Gorge both species

* A glossary of scientific names of species referred to in this paper is appended.

appear, with *Dacrydium* largely dead, outlining a recent 15-20 ft. wind roof for the most part replaced by 6-8 ft. subalpine scrub. It is noticeable that *Dacrydium* regeneration frequently appears where the ground has been recently opened to light by opossum defoliation of kamahi. *Libocedrus* here occurs patchily, and most typically in clumps in north-facing basins.

Proceeding north *Dacrydium* in stunted form at first merges with scrub on the most exposed ridges and later forms a timberline; *Libocedrus* crowns knobs and spurs at lower levels, then gains altitude, forming a timberline with *Dacrydium* in the absence of mountain beech *(Nothofagus difjortioides)*.

Libocedrus above about 3500 ft. is in poor condition with heart-rot general and regeneration confined to the lower levels along the range except on the limestone blocks capping the N.W. Ruahine Range, which are conspicuous in aerial photographs from the density of the *Libocedrus-Dacrydium* canopy. This vigour of *Libocedrus* continues westward across the tertiary of the S.W. Kaimanawa Mountains, but *Dacrydium biforme* is there replaced by *D.colensoi*.

Like the lowland podocarps *Libocedrus* has been able to maintain itself on especially favourable ground (volcanic ash in the one case, limestone in the other). Elsewhere *Libocedrus* and *Dacrydium* are in varying stages of being replaced to the the point of no return for lack of a seed source, but short of this each is capable of regenerating vigorously on ground opened by fire, slumping, defoliation or eruption. Apart from such local recovery the overall evidence is of a retreat at any rate since the date of the Taupo shower, and from Ruahine Range pollen profiles over a much longer period. The situation where over-mature trees are still dominant but with inadequate replacement is essentially a stage, though a striking one, in a fairly continuous sequence.

What at first sight appears to be an unfavourable change in environment for *Libocedrus* in the Ruahine Range is the conspicuous pattern of old trees with no replacement in sight. On further examination this turns out to be the mid-point of a much longer period of change and being a midpoint can readily be translated as an average. If this is done you arrive at a change that has been operative over the last 600 years or so, but this is in reality fixed by the life-span of *Libocredus*. Other species with different life-spans will give correspondingly different results.

The most definite patterns of change which could be put down to climate appear in beech, particularly in the mountain beech on the northern half of the Ruahine Range which is in poor condition. The timberline is irregular and has itself dropped some 200-300 ft., both changes having taken place within the past 200 years judging from the traces of a former continuous canopy which was more apparent 30 years ago. The retreating timberline is matched 150 miles north (Maungawaro), but forest of similar composition on the intervening ranges and at higher altitudes in the Kaimanawa Mountains is quite unaffected so that a general lowering of timberline can be ruled out.

Red beech (*N. fusca*) shows a tendency to retreat in the Ruahine Range mid-altitude forest which would match a retreating timberline, but this is not strongly marked. The most definite evidence of a change in conditions affecting red beech comes from the Inland Patea area. It is absent from the upper Rangitikei catchment on the northern side of the plateau, apparently as an accident of the recolonization of that side of the Kaimanawa Mountains following the Taupo eruption.

It appears, however, on the southern side of the tussock in an intermittent arc. The species seems unsuited to the present day environment. Large stag-headed trees are typical (Te Rei), red beech is usually replaced by mountain beech following fire (Tikitiki Bush is a marked exception) and the complete replacement of red beech by a black beech-mountain beech swarm over some 20 miles of this former forest fringe is peculiar as it is to some extent pre-Maori.

Returning to mountain beech the gaps in the Ruahine Range timberline invariably occur in basins and gullies where recent forest has been replaced by tussock and scrub whereas spurs and ridges remain under forest. As the range flattens out to the north, mountain beech is in process of dying off with accumulation of surface water and peat and partial replacement by *Dacrydium biforme*. In this vicinity beech regeneration becomes abundant as the slope steepens.

Conditions too wet for mountain beech might be expected to favour silver beech (*N.menziesii*). Silver beech, however, which is present in scattered colonies on the western side of the range, shows no tendency to replace mountain beech and from the pollen profiles has been present intermittently but invariably as a minor component for some 3000 years.

However, where silver beech forest meets mountain beech on the Taupo ash there is a recurrent pattern, in this case mountain replacing silver at elevations about 4500 ft., which is some 500 ft. above the maximum silver beech timberline away from Taupo ash. The pattern is of large silver beech trees often heavily branched, scattered on S. or S.E. facing slopes and surrounded by pole mountain beech. With this invariably is a belt several hundred feet down-slope of silver beech regeneration under the mountain canopy. This appears to be an early stage of the pattern where red or silver and mountain beech are associated in overlapping zones as in the Huiarau to the N.E., and to be connected rather with the ageing of the Taupo soils than with climate.

The difficulty of interpreting changes involving mountain beech is its short life of the order of 150 years at the timberline as against 450 years for silver and red beech. The most definite evidence of change lies here but it is so recent that it is contemporaneous with or masked by catastrophes of one kind or another, many of which are not changes in any recognisable direction and can only be classed as fortuitous.

The earliest of these date back 400-500 years and are fire patterns, presumably associated with Maori settlement and cultivation. The present Taupo Maoris traditionally occupied the shores of the Lake 450 years ago and the development of "Whakaota" cultivation will have meant a steady nibbling away of forest margins (accelerated by potato cultivation) until recent times. Cross country tracks were also kept open by burning and these can lead to some baffling succession patterns, the oddest of which perhaps is the rimu-manuka - leatherwood - *Dacrydium biforme* community on the divide between the Ruamahanga R. and the Manawatu drainages. There are also sporadic fires which have run wild, like the Tahu-a-Rongotea burn on the Western Ruahine Range, and have produced anomalous patterns, in this case only unravelled by the discovery of sub-surface charcoal.

The most striking evidence of catastrophe has been the gale of February, 1936, where a freak storm brought about widespread damage in the Tararua Range of an intensity that may be expected to leave traces over more than one generation of forest. The complicated patterns of damage set up by a wind of exceptional velocity were difficult to reconstruct so soon after as 20 years and the accompanying shingling up of streams is on a vast scale.

There are instances of more local and more recent damage, but of comparable intensity. One such occurred in the Oamaru Valley (Kaimanawa Mountains), in July, 1957, when a gale of unusual velocity with unusual weight of icing caused heavy snowbreak which was the start of the log jams and heavy scouring that have greatly altered the river. But for the fact that the combination of wind and icing brought down 4 miles of telephone line on the Rangitaiki Plains the unusual features of this gale would have been overlooked.

Comparable effects in three eastern valleys of the Ruahine Range were apparently caused by something in the nature of a cloudburst in August, 1954, which scoured out terraces so badly that the narrow valleys were blocked for a while by interlaced trees, including large beech and rimu 200-300 years old, and enormous deposits of shingle which took some 3 months to clear. The results in this case of an unrecorded storm are quite disproportionate.

The drought of 1945-46 killed mountain beech on deep pumice across the southern

Kaimanawa Mountains to the Kaweka Range over a distance of 30 miles. Earthquake damage is not important but has probably occurred in two localities along the East Coast fault. Catastrophe of one kind or another whose traces will persist for 100 years or more is in fact a normal hazard of the higher forests, and tends to obscure longer term trends.

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VERNACULAR — SPECIFIC NAMES

Kahikatea	*Podocarpus dacrydioides.*
Rimu	*Dacrydium cupressinum.*
Silver Beech	*Nothofagus menziesii.*
Red Beech	*N. fusca.*
Black Beech	*N. solandri* var. *solandri.*
Mountain Beech	*N. solandri* var. *cliffortioides.*
Manuka	*Leptospermum scoparium.*
Leatherwood	*Olearia colensoi;* also *Senecio elaeagnifolius.*

EVIDENCE FOR ECOLOGICALLY SIGNIFICANT CHANGES IN CLIMATE DURING THE POST-GLACIAL PERIOD IN NEW ZEALAND*

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Compared with the vast changes in geography, topography, climate, and biota during the rest of geological time, the changes of the post-glacial period are so slight that a geologist may perhaps be forgiven if he writes them off as negligible. But in fact, a universal human weakness offsets this reaction: man views the past through spectacles that exaggerate the perspective. We look back down a logarithmic time scale so that objects and events close to us have a significance far exceeding their order of importance when viewed on a linear time scale. The post-glacial period of some 15,000 years saw the spread of Neolithic and modern man and is thus infinitely more important to us than any previous period of equal duration. Moreover, the latter part of the post-glacial, the last two millenia (on which this symposium has been concentrated), overlaps the life-span of some organisms still living, to wit the slow-growing conifers, so that the botanist and ecologist must add the parameter of time to their data and think dynamically and historically, not just descriptively. The post-glacial, in consequence, becomes a notable field of overlap of disciplines.

Historically, the approach to New Zealand post-glacial changes has come from several independent types of study. The first conspicuous evidence of change came from discoveries of moa bones, and Haast, a geologist, got off on a false lead when he suggested that their extermination by an autochthonous race dated from the Quaternary, by which he meant a period much older than the younger post-glacial (see Haast, 1879). The magnitude of the faunal change, extinction of a whole assemblage of birds contemporary with the moa, led to numerous hypotheses of environmental change, some climatic. Post-glacial changes in Europe (especially Scandinavia) early influenced the interpretation of the New Zealand story; for instance Speight's (1911) conclusions that dry steppe climate of the glacial era in Canterbury had given way to moist forest climate and then to modified steppe conditions with wider grasslands to which early human fires had contributed. A threefold division of the post-glacial, with a middle period of warm wet climate, was strongly supported by Cranwell and von

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