Journal of the Royal Society of New Zealand

ISSN: 0303-6758 (Print) 1175-8899 (Online) Journal homepage: https://www.tandfonline.com/loi/tnzr20

Late Pleistocene palynology of terrestrial cover beds at the type section of the Rapanui Terrace, Wanganui, New Zealand

M. Royd Bussell

To cite this article: M. Royd Bussell (1992) Late Pleistocene palynology of terrestrial cover beds at the type section of the Rapanui Terrace, Wanganui, New Zealand, Journal of the Royal Society of New Zealand, 22:2, 77-90, DOI: 10.1080/03036758.1992.10420807

To link to this article: https://doi.org/10.1080/03036758.1992.10420807

© *Journal of the Royal Society of New Zealand,*
Volume 22, Number 2, June 1992, pp 77–90

Late Pleistocene palynology of terrestrial cover beds at the type section of the Rapanui Terrace, Wanganui, New Zealand

M. Royd Bussell*

This study investigates the vegetational and climatic history recorded by fossil pollen preserved in terrestrial cover beds at the type section of the Rapanui Marine Terrace, Wanganui, New Zealand. At this section, laterally extensive Rapanui Lignite and Rapanui Dunesand overlie marine sands of the Rapanui Formation, which were deposited after the cutting of the Rapanui marine platform during the last interglacial *sensu stricto.*

The lowermost sample, below Rapanui Lignite proper, contains a pollen assemblage derived from podocarp-hardwood forest, indicating a palaeoenvironment similar to, or cooler and drier than, the present. The Rapanui Lignite contains pollen assemblages derived from a low forest/shrubland with prominent Myrtaceae, and including a now-extinct *Acacia*-type. These assemblages are derived from vegetation lacking a modern analogue in New Zealand, and they are considered to indicate a palaeoclimate which was also cooler and possibly drier and windier than at present. The presence of *Libocedrus* and *Acacia*-type on the Wanganui lowlands during the period of deposition of Rapanui Lignite indicates important late Pleistocene biogeographic differences for these taxa, compared with the present.

Since the Rapanui Formation marine sands are estimated to be *c.* 120,000 years old, and the overlying terrestrial sediment appears to be more or less conformable, the lowermost pollen sample probably represents the end of the last interglacial (oxygen isotope substage 5e) or the transition period to the following stadial. The Rapanui Lignite is correlated with stadial oxygen isotope substage 5d, and is estimated to date to *c.* 110,000 years ago.

Keywords: pollen, Pleistocene, Rapanui Terrace, Rapanui Lignite, Rapanui Dunesand, Rapanui Formation, marine terraces, oxygen isotopes, vegetation history, climate, palaeoecology, biogeography, Acacia*-type*

INTRODUCTION

The presence of a well preserved suite of upper Pleistocene marine platforms in the south Taranaki-Wanganui district of New Zealand, at 39–45°S latitude and 173°45′–175°E longitude, offers the chance to develop a long record of vegetational and climatic history for the last 600,000 years for this region. Ages have been estimated for the cutting of the marine platforms (Pillans, 1983, 1990) and the terrestrial cover beds of the terraces contain lignites which yield abundant fossil pollen, have a distinctive loess stratigraphy (Pillans, 1988), and contain both andesitic and rhyolitic tephra marker beds, some of which have been independently dated.

A number of long, detailed vegetational and climatic histories have already been documented for different terrace cover bed sequences (*e.g.* McGlone *et al.*, 1984; Pillans *et al.*, 1988; Bussell, 1988a, 1990; Bussell and Pillans, 1992), which provide a discontinuous record of the last *c.* 400,000 yr.

---

* Shell Todd Oil Services Limited, Private Bag, New Plymouth, New Zealand

Table 1 – Nomenclature and ages of south Taranaki-Wanganui marine terraces cut during the last *c.* 350,000 yr (Pillans 1983, 1990).

Terrace	Approx. age (yr)	Correlation with oxygen isotope stage/substage
Rakaupiko	60,000	3
Hauriri	80,000	5a
Inaha	100,000	5c
Rapanui	120,000	5e
Ngarino	210,000	7
Brunswick	310,000	9
Braemore	340,000	9

This paper presents the results of pollen analysis of the cover beds of the Rapanui Terrace, which Pillans (1983) considered to have been cut *c.* 120,000 yr ago during the last interglacial (oxygen isotope substage 5e). The site investigated is the Rapanui Terrace type section (Fleming, 1953) at Castlecliff Beach, Wanganui, New Zealand (latitude 39° 55′ S, longitude 174° 57′ E, at grid reference R22/432754*; Fig. 1). It is located 80km east of the Taranaki Volcanic Centre ringplain and 100km south-southwest of the Taupo Volcanic Zone (Fig. 1).

The site was previously palynologically investigated by W.F. Harris and R.A. Couper. Their results have never been fully published, but were summarised in Fleming (1953). Unfortunately, the summary version combined data from two stratigraphically and geographically separate sites, as further discussed below.

The Rapanui Lignite Site provides a vegetational and climatic history from the end of the last interglacial to the following stadial period (end oxygen isotope substage 5e to substage 5d) that is closely linked with sea level changes. A comparison is made with other published sites from the region.

REGIONAL SETTING

Depositional setting

Table 1 presents the nomenclature and ages of the marine terraces cut during interglacial and interstadial periods of the last *c.* 350,000 yr in the south Taranaki-Wanganui district. The terrace strandlines in the area of the Rapanui Lignite site are mapped in Fig. 1.

The surfaces of the cover beds form a 15km wide coastal terraced landscape that contrasts markedly with the deeply dissected, soft marine sediments of the higher altitude hinterland. Holocene sand-dune complexes are present along the coastal areas, and the terraces are abruptly cliffed northwest of Wanganui except where major rivers intersect the coast.

To the northwest, Mt Taranaki (Egmont) is a 2518m high, presently dormant late Pleistocene andesitic stratovolcano. The present massif is less than 10,000 years old (Neall *et al.*, 1986) but there are older centres of the Taranaki Volcanic Zone northwest of Mt Taranaki, which date back to 1.74 ± 0.03 Myr (Neall, 1979). The local Pleistocene volcanic activity has been largely restricted to pyroclastic deposition on the ringplain, but tephra was at times distributed southeast to the Wanganui district. To the north-northeast, the Taupo Volcanic Zone has been a major centre of rhyolitic and andesitic volcanism in the late Pleistocene, and has sourced important rhyolitic marker tephra in the Taranaki sequence.

---

* Grid references and fossil locality numbers are recorded in the N.Z. Fossil Record File and are based on the national thousand metre grid of the 1:50,000 map series, NZMS260

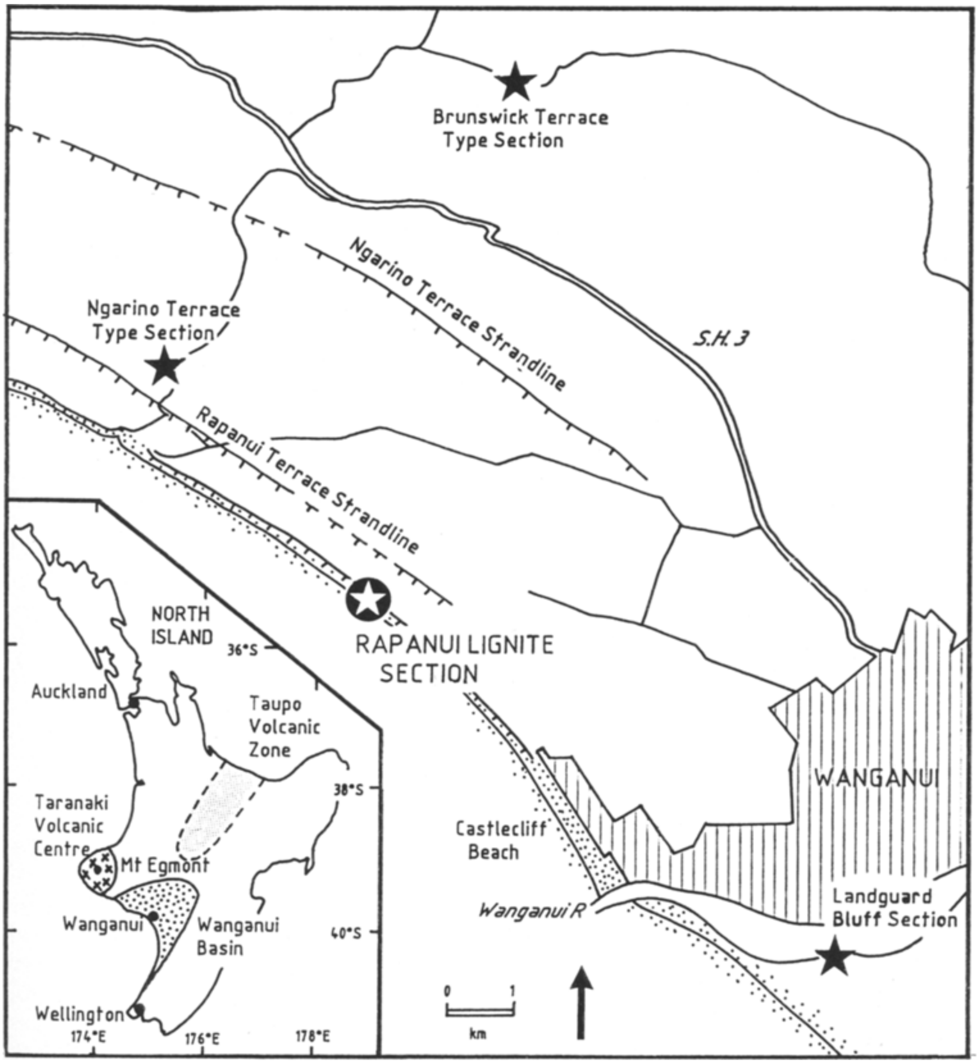

Fig. 1 – Location of the Rapanui Lignite Site in relation to the mapped strandlines of marine terraces (after Pillans, 1990).

Major rivers in the area are thought to have had floodplains which acted as sources for widespread loess deposits while they aggraded terraces during cool-climate phases of the last *c.* 300,000 yr (Milne, 1973).

Climate

Coastal regions, such as Wanganui, currently enjoy a mild, warm-temperate climate with few extremes, while cooler annual average temperatures and higher average rainfall are experienced in hinterland regions, and frosts and fogs may be common. Annual rainfall at Wanganui is 900 mm and is evenly distributed through the year. Mean annual temperature at Wanganui is 13.6°C. West and northwest winds prevail with relatively frequent gales.

Vegetation

Except for small pockets, there is little remaining of the coastal-lowland forests that once covered the south Taranaki-Wanganui district. Present land usage is principally for dairy farming, and rich pasture grows on the freely draining, fertile, yellow-brown earth soils of the terrace surfaces.

The original coastal to semi-coastal forest comprised a low canopy of *Dysoxylum spectabile, Rhopalostylis sapida, Corynocarpus laevigatus, Beilschmiedia tawa, Elaeocarpus dentatus, Alectryon excelsus, Hedycarya arborea,* and *Laurelia novaezelandiae* (Esler, 1978).

Podocarp-hardwood forest dominated by a canopy of *Beilschmiedia tawa* covered lowland areas inland from Wanganui. Podocarps such as *Dacrydium cupressinum, Prumnopitys taxifolia, P. ferruginea, Podocarpus totara,* and *Dacrycarpus dacrydioides* emerged above this canopy, together with the hardwood *Metrosideros robusta*. Poorly drained areas supported dense stands of *D. dacrydioides*.

Further inland, behind the oldest marine terrace remnants, *Nothofagus solandri* var. *solandri* forms ridgeline forests (above *c*. 450m) on the poorer soils. The associated canopy trees are *Weinmannia racemosa* (which altitudinally replaces *Beilschmiedia tawa), Podocarpus hallii* (which altitudinally replaces *P. totara),* and *B. tawa* (Nicholls, 1956).

Clarkson (1985, 1986) described the altitudinal vegetation zones of Egmont National Park, and the vegetation communities of central-western North Island have been briefly described by Bussell (1988b). On Mt Taranaki, where *Nothofagus* is absent, montane podocarp-hardwood forest forms the timberline at *c*. 1050m, replaced at successively higher altitudes by subalpine shrubland, grassland, herbfield, and mossfield. Holocene volcanic activity has strongly affected Mt Taranaki vegetation (Druce, 1966) but the influences of the volcano on vegetation elsewhere have probably been largely confined to the ringplain. Pleistocene volcanic activity in the distant Taupo Volcanic Zone is unlikely to have severely influenced vegetation in south Taranaki-Wanganui except along the valleys of major rivers which have their headwaters in that region.

THE RAPANUI LIGNITE SECTION

Local terrace sequence

The Rapanui Lignite Section at Castlecliff Beach, Wanganui, is a cliff exposure of the Rapanui Terrace marine platform and associated cover beds originally mapped and described by Fleming (1953) as the type locality for the Rapanui Formation. Lensen (1959) regionally mapped the marine terrace sequence at Wanganui, and Dickson *et al*. (1974) differentiated the older Ngarino Terrace from the previously mapped Rapanui. The strandline of the Rapanui Terrace is preserved inland from Castlecliff Beach (Fig. 1). Pillans (1983, 1990) recognised two marine terraces younger than the Rapanui, the Inaha and Hauriri Terraces west of the Rapanui Lignite Section, previously mapped as the Rapanui Terrace. Pillans (1983) assigned an age of *c*. 120,000 yr for the cutting of the Rapanui marine platform.

Pillans (1990) mapped the terrace sequence at 1:100,000 scale and formally described and defined each terrace. In contrast to Fleming's (1953) usage, the Rapanui Formation is restricted to include only the marine cover beds of the Rapanui Terrace that overlie the wave cut platform (the "Rapanui Marine Sand" of Fleming, 1953). The terrestrial cover beds of the Rapanui Terrace are considered here to include the Rapanui Lignite and Rapanui Dunesand, but not the Waipuna Delta Conglomerate or Kaiwhara Alluvium. The Waipuna Delta Conglomerate has been shown by Pillans *et al*. (1988) to be a littoral deposit within the Ngarino Terrace marine cover beds, while the Kaiwhara Alluvium has been retained for describing sediments of many depositional settings at Landguard Bluff (Ngarino Terrace: Pillans *et al*., 1988).

Stratigraphy (Fig. 2)

The Rapanui Lignite Site exposes some 13 m of cover beds of the Rapanui Terrace in a cliff at the back of Castlecliff Beach (Fig. 2). A marine platform at 29 m a.s.l. (13 m below terrace surface) is unconformably cut into neritic sediments of the Shakespeare Group. The

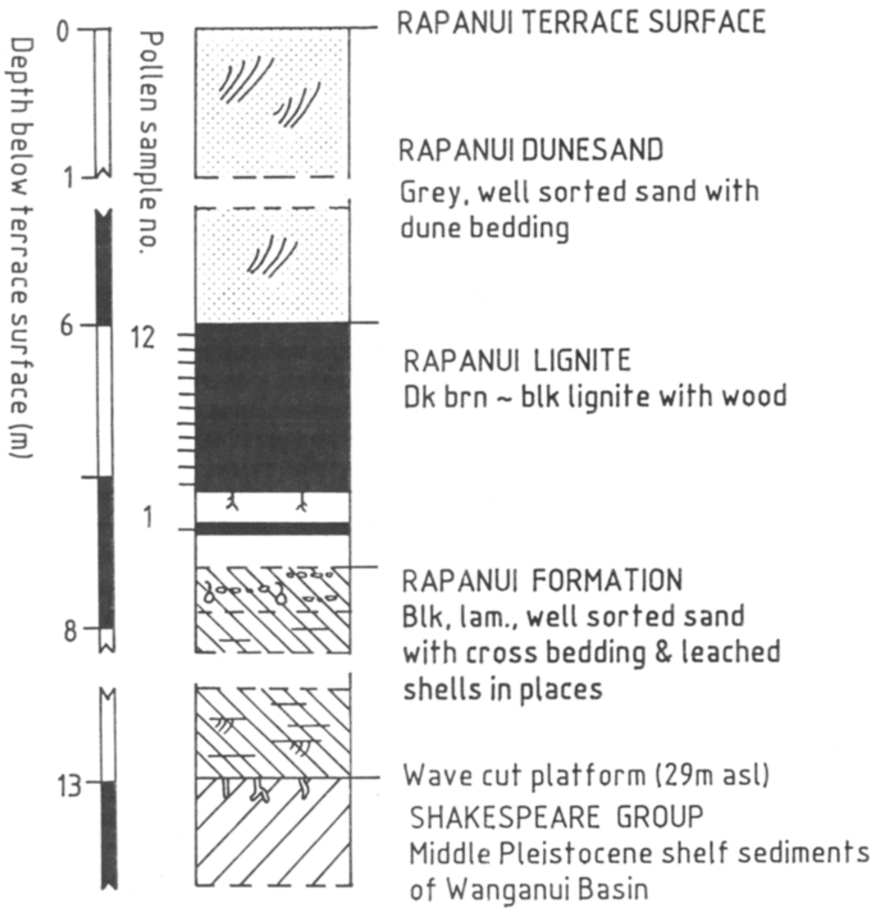

Fig. 2 – Stratigraphy of the Rapanui Lignite Site (type section of the Rapanui Terrace, Castlecliff Beach, Wanganui).

marine cover beds comprise 5 m of littoral sands with rare leached shells. This is overlain by 0.5 m of sands of probable terrestrial origin, which include a thin lignaceous layer from which the lowermost pollen sample was taken. The Rapanui Lignite overlies and comprises 1.2 m of thick, dark brown lignite; then there is some 6 m of Rapanui Dunesand to the current terrace surface, which has no loess or soil development on it at the pollen site.

Dating

Pillans (1983, 1990) considered the Rapanui marine platform to have been cut at *c.* 120,000 yr ago, that is, during the last interglacial (oxygen isotope substage 5e) marine transgression. This age was calculated using an uplift model for the suite of marine platforms in the region, calibrated with a fission track date on a rhyolitic tephra in the cover beds of an older terrace. The age is also supported by amino acid racemisation dates on Rapanui Lignite, which average *c.* 110,000 yr ago (Pillans, 1990). Furthermore, loess stratigraphy in the region suggests that four loess units overlie the Rapanui Terrace, and the oldest loess ('L4') was considered by Pillans (1988) to be *c.* 100,000–120,000 yr old. Since the Rapanui Lignite closely overlies the marine cover beds in an apparently conformable sequence, and because the site is close to the terrace strandline, then the Rapanui Lignite may be expected to date soon after the time of terrace cutting.

PALYNOLOGY

Methods

Pollen samples were analysed from 10 cm intervals within the Rapanui Lignite, and one sample was analysed from a lower lignaceous horizon (Fig. 2). Sample processing methods follow those of Faegri and Iversen (1975). The sample residues were placed in silicone oil, and slides containing 0.02 ml of suspended sample were prepared and wax-sealed.

A minimum pollen sum of 280 was achieved for all samples. The pollen sum used includes all terrestrial pollen except *Leptospermum*-type and was aimed at providing the clearest information on the extra-local and regional vegetation (Jacobson and Bradshaw, 1981). Bussell (1988a) discusses the choice of this pollen sum in more detail. Charcoal particle areas were also measured for all samples using the method described by Clark (1982).

Interpretation of the pollen assemblages is based partly on modern pollen studies from the region (McGlone, 1982; Bussell, 1988b) and by comparison between the assemblages sampled and those recorded from the Holocene and last glaciation in the area (McIntyre, 1963, 1970; McGlone, 1980; Bussell, 1988c). Norton *et al.* (1986) have shown that selected modern pollen spectra in New Zealand correlate with modern vegetation associations, and that the abundance of certain pollen taxa correlates well with some climatic parameters. Analogues are also made from present day vegetation-climate relationships.

Fig. 3 shows a pollen diagram from the Rapanui Lignite Site. Raw pollen counts for taxa shown in the pollen diagrams and for other taxa not shown are contained in Bussell (1988a). All samples contained abundant, although corroded, pollen.

The pollen diagram

No local pollen zones are designated for this site, although the single sample from the lower thin lignaceous unit does show some important differences.

The lowermost pollen sample from 7.38m (sample 1, Fig. 3) is dominated by the pollen of *Dacrydium cupressinum*; pollen of *Prumnopitys taxifolia* and *Coprosma*, and spores of *Cyathea*, are common.

The two pollen samples from the base of the Rapanui Lignite (samples 2 and 3, Fig. 3) have substantially reduced percentages for gymnosperm tree pollen compared with sample 1, and an unusual assemblage dominated by *Metrosideros*-type pollen at levels up to 83%. Because the pollen was not well preserved, identification of separate taxa within the Myrtaceae was more tentative than usual, and although I felt that much of the pollen present in these and overlying samples was *Metrosideros*, some may be attributable to either *Neomyrtus*-type or, in the case of samples 2 and 3 particularly, the semi-swamp tree *Syzygium maire*.

Pollen samples 4–12 (Fig. 3) have lower amounts of *Metrosideros*-type pollen, and there is general decline of this type upwards through the Rapanui Lignite. *Coprosma* pollen, on the other hand, shows a marked upward increase in abundance, with a maximum of 67%. *Leptospermum*-type pollen also shows upward rise, with a maximum below the top of 130% (it is excluded from the pollen sum). *Libocedrus* pollen is common throughout the Rapanui Lignite, averaging *c.* 5%, and shows a peak of 16% in the uppermost sample (sample 12, Fig. 3). *Nothofagus menziesii* pollen is consistently present at low levels from samples 5–12. Grass pollen is common in the middle of the Rapanui Lignite, but is sparse in other samples. Asteraceae (Tubuliflorae) and *Phyllocladus* pollen are most common in the upper half. *Acacia*-type polyads comprise 1% of the pollen sum in sample 6. Local swamp pollen is sparse in the lower half of the pollen sequence, but sedge, rush and *Phormium* pollen are common in the middle and upper Rapanui Lignite. *Phormium* pollen is abundant (55%) in sample 5, and declines upward. Fern spores are not prolific in this pollen sequence, and spores of *Cyathea*, the most common taxon represented, are most common in the lower half of the pollen sequence. Charcoal particles are present but infrequent throughout the pollen sequence, except in sample 10, where they reach a peak of 33 cm^2/cm^3.

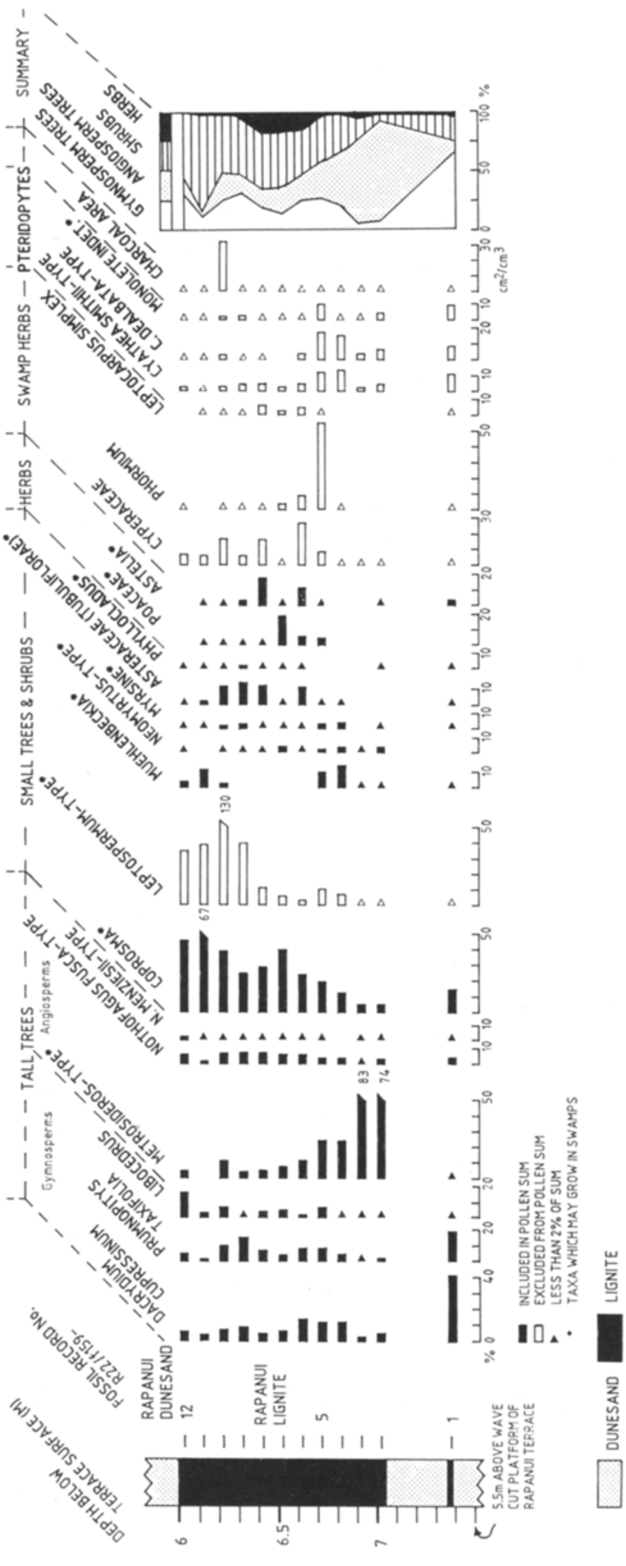

Fig. 3 – Pollen diagram from the Rapanui Lignite Site showing selected taxa. Pollen sum = terrestrial pollen minus *Leptospermum*-type. Numbers 1–12 on the right hand side of the profile show the positions of the samples.

Table 2 – Summary of vegetational and climatic changes recorded at the Rapanui Lignite Site, and their interpretation in terms of climatic stages

Samples	Extra-local vegetation	Climate (compared with present)	Stage	Inferred oxygen isotope substage
Rapanui Lignite (2–12)	Shrubland-low forest with Myrtaceae and *Acacia*-type	Cooler, drier and windier	Stadial	5d
Lowest sample (1)	Podocarp-hardwood forest	Similar, or cooler and drier	End of interglacial or transition to stadial	5e–5d

VEGETATIONAL AND CLIMATIC HISTORY (Table 2)

Local environmental and vegetational history

During an interglacial period of high sea level, the sea cut the Rapanui Terrace marine platform and deposited marine sediment at the site. Following regression, coastal sand-dunes probably formed, and these were forested where stable. A small inter-dune hollow at the site was most likely occupied by forest, as few pollen grains derived from swamp herbs are represented in sample 1 (Fig. 3). Some pollen of the semi-swamp tree *Dacrycarpus dacrydioides* is present, but this species is unlikely to have been dominant. The local and extra-local arboreal communities may have been similar at this time, so *Dacrydium cupressinum* is envisaged as growing on the site. The presence of the aquatic *Myriophyllum* at this time suggests open water conditions, even if only for a brief period, and *D. cupressinum* apparently can tolerate standing in waterlogged soils once a surface layer of humus has formed (Franklin, 1968).

Some time later, a more permanent and more extensive swamp was established, presumably as a result of stabilisation of the site. Because the Rapanui Lignite is laterally continuous, it must represent a very extensive, poorly drained area. The depositional setting is envisaged as a dune-impounded swamp, although the coast need not have been close to the site.

Initially, semi-swamp forest probably grew on the site, because pollen derived from swamp herbs is scarce. One possibility is that the site may have been dominated by the small swamp tree *Syzygium maire*. Later, the local water table rose to allow the establishment of a sedge-*Phormium* community, in which the rush *Leptocarpus similis*, and the herb *Astelia*, were common (samples 5–12, Fig. 3). *Syzygium*, if dominant earlier, became excluded from the swamp at this time. This community indicates the swamp was fertile. No such extensive swamps of this nature have survived on the Taranaki-Wanganui lowlands to the present day. *Lagarostrobos colensoi* probably grew locally.

Dune activity then overwhelmed the site, after which peat was no longer deposited locally.

Extra-local and regional vegetation history

Initially (sample 1, Fig. 3) the site may have been surrounded by podocarp – ?hardwood forest dominated by *Dacrydium cupressinum*, and with common *Prumnopitys taxifolia*. However the hardwood trees appear to be sparsely represented in the pollen record, probably because they are masked by the high local pollen input of podocarp trees growing on the site, so little can be said of the extra-local forest composition. Likewise, the relative proportions of the podocarp trees may be misleadingly represented in the pollen spectrum because of masking by *D. cupressinum*.

During the time of Rapanui Lignite deposition, the record suggests that the forest in the extra-local community was restricted in extent, even allowing for palynological masking by the abundant *Metrosideros*-type representation in samples 2 and 3 (Fig. 3). Shrubland/low forest, principally comprising *Coprosma, Leptospermum*-type, *Muehlenbeckia, Neomyrtus*-type, *Myrsine,* and probably *Metrosideros,* may have been the dominant extra-local vegetation at the time of deposition of the lower part of the lignite. This vegetation may have been associated with dune country. Further inland, some podocarp – hardwood forest was probably present.

Later (samples 5–7, Fig. 3), it appears that some open areas occupied by grassland were present nearby. One source of grass pollen may have been from the sandbinder *Spinifex hirsutus,* which could have been common if there were sand-dunes present in the area. *Coprosma* became more common in the surrounding shrubland, and the presence of the now extinct *Acacia*-type indicates that this community does not have a present day analogue. Many of the pollen taxa that are prominent at this time have representatives in the modern flora in coastal to semi-coastal sand-dune scrub. The assemblage and stratigraphic setting (associated with dune-sand) is typical of other assemblages from older deposits in which *Acacia*-type has been identified (*e.g.* Mildenhall, 1972, 1975a, 1975b; Bussell and Mildenhall, 1990). *Libocedrus* was apparently common in the extra-local vegetation, as suggested by pollen records of up to 6% of the sum for this palynologically under-represented tree (McGlone, 1982; Bussell, 1988b). It may have formed isolated pockets of forest perhaps on the margins of interdune hollows, as it presently prefers poorly drained sites (Elder, 1965).

During the time represented by the middle and upper Rapanui Lignite, shrubland/low forest remained the dominant extra-local vegetation community, but *Coprosma* and *Leptospermum*-type increased in abundance. Asteraceae (Tubuliflorae) became common. *Acacia*-type may well have still been present, because Australian modern pollen rain studies have shown that *Acacia* pollen is severely under-represented in most samples (Dodson, 1977, 1983). In the regional forests *Nothofagus fusca*-type and *N. menziesii* increased, but they were most probably not present in the Wanganui lowland. The presence of 16% *Libocedrus* pollen in the uppermost sample (12, Fig. 3), indicates that this tree must have been abundant in the extra-local vegetation of that time.

Climatic history

The lowermost pollen sample (1, Fig. 3) is considered to indicate warm, wet conditions, probably not too dissimilar from the present climate of Wanganui if *Dacrydium cupressinum* was dominant in the podocarp – hardwood forest of the region. However, there is an alternative interpretation, which considers *D. cupressinum* as purely local, and in which *Prumnopitys taxifolia* is the extra-local dominant tree of podocarp – hardwood forest; this scenario suggests cooler, drier conditions than the present.

The vegetation recorded in the Rapanui Lignite itself certainly represents a cooler, probably drier climate than present. This is suggested by (1) the scarcity of pollen from podocarp – hardwood forest, even considering the local masking effects of the common pollen types, and also by (2) the presence of 'cool-climate taxa', principally *Libocedrus,* on the Wanganui lowlands. Some shrubland/low forest may have lived among local sand-dunes; however, many taxa associated with recent pre-clearance coastal to semi-coastal forests on dune country (*e.g. Dodonaea viscosa* and *Rhopalostylis sapida*), are apparently absent, and this would be expected if the climate was cooler than now.

The 1% representation of *Acacia*-type polyads suggests this taxon was growing in vegetation near to the site. Mildenhall (1975a) considered *Acacia*-type pollen to indicate dry, cool to mild, coastal environments, as it was found in assemblages also containing scrub and grassland species, and apparently, coastal swamp sedges. I consider that the site examined here was inland from the coast proper at the time the Rapanui Lignite was deposited, because the sea had regressed after cutting the Rapanui Terrace, and the cooler climate (indicated by the restriction of forest and the presence of cool climate taxa) suggests that the sea level was by inference much lower than at the present day. Sea level fell after the last interglacial, from

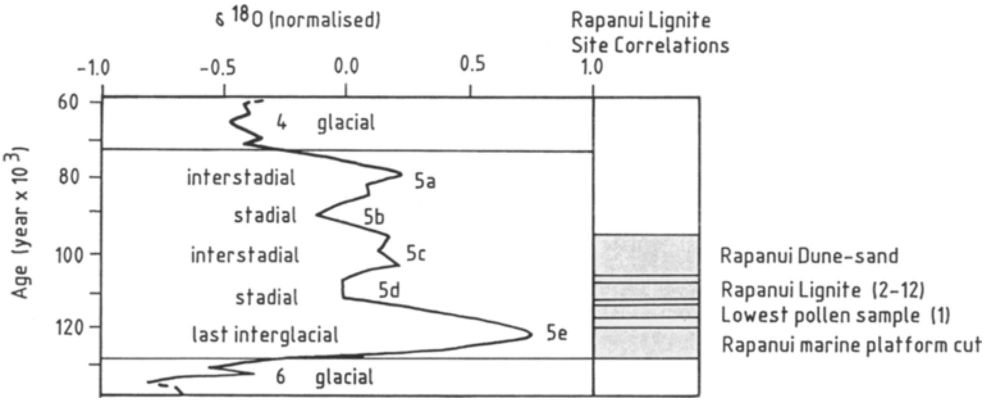

Fig. 4 – Correlation of the Rapanui Lignite Site with the deep sea oxygen isotope record (after Martinson *et al.*, 1987).

+2 m at *c.* 120,000 years ago to –54 m at *c.* 112,000 years ago (Chappell and Shackleton, 1986). Bathymetric data of Lewis and Eade (1974) indicate that a *c.* 50 m sea level fall would produce little change in the palaeogeography of the Wanganui district, but the pollen site would lie some 18 km from the coast at *c.* 112,000 years ago. I consider that the sequence does not contain any important unconformity overlying the marine sediments, and therefore, I infer that the pollen site was most likely part of a lowland plain subject to semi-coastal conditions. I envisage the site as having been subject to frequently cool, dry, possibly windy climatic conditions.

Fire was generally not important in controlling the local to extra-local vegetation, because the charcoal area curve (Fig. 3) shows that there was little charcoal deposition into the site except during the period recorded by sample 10, which records a peak in measured charcoal area.

Although andesitic tephra were reported by Fleming (1953) within Rapanui Lignite, they are not present as prominent horizons in the Lignite at the pollen site, and I do not envisage any influence of volcanism on the vegetation during the time represented by the pollen sequence.

Age and correlation of the Rapanui Lignite site

I consider the lowermost pollen sample to represent the end of the interglacial during which the Rapanui Terrace was cut, because the deposits which this sample came from rest with apparent conformity on the marine deposits of the interglacial, and the pollen assemblage is similar either to the present or to an early post-glacial vegetation of the field area. Thus it is correlated with the end of oxygen isotope substage 5e, or the 5e to 5d transition (Fig. 4). I consider the overlying Rapanui Lignite to represent oxygen isotope substage 5d because, although there may be no exact analogues of some of the communities present at that time, stadial conditions are likely, judging from the pollen assemblages; and the apparently conformable relationship with underlying deposits suggests that the deposits correlate with the stadial immediately following the last interglacial marine transgression. These correlations are shown in Fig. 4 and Table 2. These results tie well with the mean amino acid racemisation dates reported by Pillans (1990) from the Rapanui Lignite.

DISCUSSION

Previous palynological study of Rapanui Lignite

The pollen analytical sequence reported here differs markedly from data reported from the Rapanui Lignite by W.F. Harris and R.A. Couper in Fleming (1953). They reported presence/

absence data for taxa in the Rapanui Lignite, and combined the quantitative results with counts for the same taxa from all samples from the Rapanui Lignite and from the much older Landguard Lignite exposed at Landguard Bluff, Wanganui (Fig. 1). For this reason their data cannot sensibly be compared with the results of this study. Harris and Couper summarised their data by stating that there was "no evidence of marked climatic change during the period of formation" and "the climate was not unlike the present". Their conclusions differ markedly from mine: I consider cooler conditions than present to have prevailed during the Rapanui Lignite deposition. Two possible explanations for the differences are (1) that they sampled the Rapanui Lignite in a different location from this study, and (2) that the lignite is time transgressive. The Castlecliff Beach section is now poorly exposed compared with its condition at the time of Fleming's (1953) field work. Fleming's diagrams of the coastal sections do not indicate any interfingering of separate members of Rapanui Lignite – rather, it is shown as a continuous stratigraphic unit with thickness variations. My field investigations, however, indicate that the Rapanui Lignite is discontinuous along the Castlecliff coastal section, and cannot be assumed to be coeval in all locations. Holocene lignites exposed at Waverley Beach, which were deposited in a setting similar to that of the Rapanui Lignite, have been shown to be diachronous (Bussell, 1988b).

Comparison with nearby sites

Published detailed Pleistocene vegetational histories from the Taranaki-Wanganui district include those of Dickson *et al.* (1974), McGlone *et al.* (1984), Pillans *et al.* (1988), Bussell (1990), and Bussell and Pillans (1992). The pollen spectrum from the lowermost sample at the Rapanui Lignite Site is similar to the interglacial pollen assemblages reported from pollen Zone 3 at the Landguard Bluff Site, Wanganui (Pillans *et al.*, 1988) and from uppermost pollen Zone OH5 at the Ohawe East Site, Hawera (Bussell, 1990). All these assemblages lack common *Ascarina* pollen, distinctive of interglacial maxima in this region (Bussell, 1988a; Bussell and Pillans, 1992). At Landguard Bluff, Zone 3 is correlated with an older interglacial than at the Rapanui Lignite Site. However, it is possible that the upper pollen zone OH5 at Ohawe East could be broadly contemporaneous with the lower pollen sample at the Rapanui Lignite Site (late oxygen isotope substage 5e).

None of the above published studies report pollen assemblages similar to those I found in the Rapanui Lignite. The distinctive features of Myrtaceae pollen dominance with common *Libocedrus* and sporadic *Acacia*-type pollen is not typical of older Tertiary pollen assemblages either[1], and has no modern analogue in New Zealand vegetation.

The Rapanui Lignite may also be partially contemporaneous with strata exposed in a site on the Waikanae River, 105 km south of Wanganui (Fleming, 1972; Mildenhall, 1973). Samples analysed from the Waimahoe Lignite, which overlies last interglacial Otaki Dunesand, contain similar pollen assemblages to those in Rapanui Lignite. The Waimahoe Lignite analyses have never been fully published, which prevents a detailed comparison at present.

Biogeography

The Rapanui Lignite contains some pollen types sourced from taxa that are now either extinct in New Zealand, not present in south Taranaki-Wanganui, or are present in Taranaki but grow at higher altitude locations.

Three *Acacia*-type polyads are present in sample 6. Since this taxon is typically severely under-represented in modern pollen rain in Australia (Dodson, 1977, 1983), the implication for the Rapanui Site is that the source plants were growing locally at the time represented by sample 6. *Acacia*-type pollen-producing taxa are now extinct in New Zealand, yet, as more fully discussed by Bussell and Mildenhall (1990), these results indicate that *Acacia*-type

---

[1] Assemblages reported by Mildenhall (1975a,b) are similar but lack common *Libocedrus* pollen.

plants were present in the late Pleistocene in Wanganui district. The Rapanui Lignite Site provides the youngest known occurrence of *Acacia*-type pollen in New Zealand.

The presence of common *Libocedrus* on the Wanganui lowlands during the deposition of the Rapanui Lignite indicates a substantial difference in the late Pleistocene biogeographic range of this taxon compared with today. At present, *Libocedrus bidwillii* grows mainly in upper montane forest on Mt Taranaki (Egmont) in western Taranaki, in the Ruahine Ranges 90 km east of Wanganui, and on the central North Island volcanic mountains. Without macrofossil evidence it is difficult certainly to exclude the possibility that the pollen encountered may be derived from the small tree *L. plumosa*, which is now absent from south Taranaki-Wanganui but grows in lowland forest in northwest Nelson (South Island) and north of around latitude 38°S in North Island. However, given the associated pollen assemblages for *Libocedrus*, it seems more reasonable to assume that the pollen is derived from *L. bidwillii*.

Nothofagus menziesii, *Lagarostrobos colensoi*, and *Phyllocladus* pollen are present at levels up to 2% in Rapanui Lignite. None of these taxa now live in south Taranaki-Wanganui, but were present in the area in the late Pleistocene during times of cooler climate than present (McGlone, 1980; McGlone *et al*., 1984; Pillans *et al*., 1988; Bussell, 1988a, 1990). The low levels recorded in this study should not be taken to confirm their certain presence in the Wanganui lowlands during the time of deposition of Rapanui Lignite, since long distance dispersal of some of these pollen types cannot be ruled out (Macphail and McQueen, 1983).

The examples given above, for *Libocedrus* and *Acacia*-type in particular, indicate significant differences in Pleistocene biogeography in south Taranaki-Wanganui compared with the present. Further details of the ancient vegetation at the Rapanui Lignite Site and elsewhere are hidden by our present inability to resolve the identification of many pollen types beyond the generic level.

CONCLUSIONS

1. The Rapanui Lignite Site contains pollen assemblages derived from "late interglacial" podocarp-hardwood forest and stadial low forest/shrubland. The climate is inferred to have been initially similar to, or slightly cooler and drier than at present, then much cooler and possibly drier and windier than at present during Rapanui Lignite deposition.
2. The lowermost pollen sample is correlated with late last interglacial oxygen isotope substage 5e or the following transition period to stadial oxygen isotope substage 5d, which is represented by Rapanui Lignite, considered to be *c.* 110,000 years old.
3. Pollen assemblages in Rapanui Lignite are derived from vegetation that has no modern equivalent in New Zealand, and which included the now extinct *Acacia*-type.
4. There have been considerable changes in the late Pleistocene ranges of some taxa in south Taranaki-Wanganui compared with the present.

ACKNOWLEDGEMENTS

Professor J. Chappell, Dr. G. Singh, Dr. B. Pillans, and D. Mildenhall are thanked for advice and review of this study. D. Clark and M. Milne kindly typed the manuscript.

REFERENCES

Bussell, M. R., 1988a. *Quaternary vegetational and climatic changes recorded in cover beds of the South Wanganui Basin marine terraces, New Zealand.* Unpublished Ph.D. dissertation, The Australian National University, Canberra.

——— 1988b. Modern pollen rain, central-western North Island, New Zealand. *N.Z. Journal of Botany* 26: 297–315.

——— 1988c. Mid and late Holocene pollen diagrams and Polynesian deforestation, Wanganui district, New Zealand. *N.Z. Journal of Botany* 26: 431–451.

——— 1990. Palynology of oxygen isotope stage 6 and substage 5e from the cover beds of a marine terrace, Taranaki, New Zealand. *Quaternary Research* 34: 86–100.

Bussell, M. R. and Mildenhall, D. C., 1990. Extinct palynomorphs from middle and late Pleistocene terrestrial sediments, South Wanganui Basin, New Zealand. *N.Z. Journal of Geology and Geophysics* 33: 439–448.

Bussell, M. R. and Pillans, B. J., 1992. Vegetational and climatic history during oxygen isotope stage 9, Wanganui district, New Zealand, and correlation of the Fordell Ash. *Journal of the Royal Society of N.Z.* 22: 41–60.

Chappell, J. and Shackleton, N. J., 1986. Oxygen isotopes and sea level. *Nature* 324: 137–140.

Clark, R. L., 1982. Point count estimation of charcoal in pollen preparations and thin sections of sediments. *Pollen et Spores* 24: 523–535.

Clarkson, B. D., 1985. The vegetation of the Kaitake Range, Egmont National Park, New Zealand. *N.Z. Journal of Botany* 23: 15–31.

——— 1986. Vegetation of Egmont National Park, New Zealand. *National Park Scientific Series* 5.

Dickson, M., Fleming, C. A., and Grant-Taylor, T. L., 1974. Ngarino Terrace: an addition to the late Pleistocene standard sequence in the Wanganui-Taranaki district. *N.Z. Journal of Geology and Geophysics* 17: 789–98.

Dodson, J. R., 1977. Pollen deposition in a small closed drainage basin lake. *Review of Palaeobotany and Palynology* 24: 179–193.

——— 1983. Modern pollen rain in southeastern New South Wales, Australia. *Review of Palaeobotany and Palynology* 38: 249–268.

Druce, A. P., 1966. Tree-ring dating of recent volcanic ash and lapilli, Mt Egmont. *N.Z. Journal of Botany* 4: 3–41.

Elder, N. L., 1965. Vegetation of the Ruahine Range: an introduction. *Transactions of the Royal Society of N.Z.* 3: 13–66.

Esler, A. E., 1978. *Botany of the Manawatu*. New Zealand Department of Scientific and Industrial Research Information Series 127.

Faegri, K. and Iversen, J., 1975. *Textbook of pollen analysis, 3rd ed.*. Blackwell, London.

Fleming, C. A., 1953. The geology of Wanganui Subdivision. *N.Z. Geological Survey Bulletin* 52.

——— 1972. The contribution of ^{14}C dates to the Quaternary geology of the 'Golden Coast', western Wellington. *Tuatara* 19: 61–69.

Franklin, D. A., 1968. Biological flora of New Zealand. 3. *Dacrydium cupressinum* Lamb. (Podocarpaceae) rimu. *N.Z. Journal of Botany* 6: 493–513.

Jacobson, G. L. and Bradshaw, R. H. W., 1981. The selection of sites for paleovegetational studies. *Quaternary Research* 16: 80–96.

Lensen, G. J., 1959. Sheet 10 – Wanganui. *Geological map of New Zealand 1:250,000.* Department of Scientific and Industrial Research, Wellington.

Lewis, K. B. and Eade, J. V., 1974 Sedimentation in the vicinity of the Maui Gas Field. *N.Z. Oceanographic Institute Oceanographic Summary* 6.

McGlone, M. S., 1980. *Late Quaternary vegetation history of central North Island, New Zealand.* Unpublished Ph.D. dissertation, University of Canterbury, Christchurch.

——— 1982. Modern pollen rain, Egmont National Park, New Zealand. *N.Z. Journal of Botany* 20: 253–262.

McGlone, M. S., Neall, V. E., and Pillans, B. J., 1984. Inaha Terrace deposits: a late Quaternary terrestrial record in south Taranaki, New Zealand. *N.Z. Journal of Geology and Geophysics* 27: 35–49

McIntyre, D. J., 1963. Pollen analysis of a peat in Koputaroa Dunesand. Appendix *in* Cowie, J. D. Dune-building phases in the Manawatu district, New Zealand. *N.Z. Journal of Geology and Geophysics* 6: 268–80.

——— 1970. Pollen analysis in the Lindale section, Paraparaumu. Appendix *in* Fleming, C.A. Radiocarbon dating and pollen analyses from Otiran periglacial fans in western Wellington. *Transactions of the Royal Society of N.Z. (Earth Sciences)* 7: 197–208.

Macphail, M. K. and McQueen, D. R., 1983. The value of New Zealand pollen and spores as indicators of Cenozoic vegetation and climates. *Tuatara* 26: 37–59.

Martinson, D. G., Pisias, N. G., Hays, J. D., Imbrie, J., Moore, T. C. Jr, and Shackleton, N. J., 1987. Age dating and the orbital theory of the ice ages: development of a high resolution 0–300,000-year chronostratigraphy. *Quaternary Research* 27: 1–29.

Mildenhall, D. C., 1972. Fossil pollen of *Acacia* type from New Zealand. *N.Z. Journal of Botany* 10: 485–94.

——— 1973. Problem of interpretation of two pollen diagrams from an Otiran (uppermost Pleistocene) section near Waikanae. *In*: Te Punga, M. T.; Mildenhall, D. C. (eds) IX INQUA *Congress guidebook for excursion A13, western North Island,* Pp 134–136.

——— 1975a. Palynology of the *Acacia*-bearing beds in the Komako District, Pohanginia Valley, North Island, New Zealand. *N.Z. Journal of Geology and Geophysics* 18: 209–28.

——— 1975b. Lower Pleistocene palynomorphs from the Ohuka carbonaceous sandstone, southwest Auckland, New Zealand. *N.Z. Journal of Geology and Geophysics* 18: 675–81.

Milne, J. D. G., 1973. Maps and sections of river terraces in the Rangitikei Basin, North Island, New Zealand. 4 sheets, *N.Z. Soil Survey Report* 4.

Neall, V. E., 1979. Sheets P19, P20, and P21. New Plymouth, Egmont, and Manaia (1st ed.), *Geological map of New Zealand 1:50,000.* Three maps and notes (36p). New Zealand Department of Scientific and Industrial Research, Wellington.

Neall, V. E., Stewart, R. B., and Smith, I. E. M., 1986. History and petrology of the Taranaki volcanoes. *In Late Cenozoic volcanism in N.Z. Royal Society of New Zealand Bulletin* 23: 251–263.

Nicholls, J. C., 1956. The historical ecology of the indigenous forest of the Taranaki upland. *N.Z. Journal of Forestry* 7:17–34.

Norton, D. A., McGlone, M. S., and Wigley, T. M. L., 1986. Quantitative analyses of modern pollen – climate relations in New Zealand indigenous forests. *N.Z. Journal of Botany* 24: 331–342.

Pillans, B. J., 1983. Upper Quaternary marine terrace chronology and deformation, south Taranaki, New Zealand. *Geology* 11: 292–297.

——— 1988. Loess chronology in Wanganui Basin, New Zealand. *Proceedings of the International Symposium on Loess, Palmerston North.*

——— 1990. Late Quaternary marine terraces, South Taranaki – Wanganui. *N.Z. Geological Survey Miscellaneous Series Map* 18.

Pillans, B. J., Holgate, G., and McGlone, M., 1988. Climate and sea level during oxygen isotope stage 7b: on land evidence from New Zealand. *Quaternary Research* 29: 176–185.

Received 26 July 1991; accepted 19 November 1991