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Mangroves (*Avicennia marina* var. *resinifera* (Forst.f.) Bakh.) lived in the Poverty Bay-East Cape region during the early to mid Holocene for about 4,000 years, from c. 9,800–6,000 years BP. This suggests an essentially frost-free climate at least one degree warmer than the present day, as required to allow germination and growth of *Avicennia* seedlings. Sea levels were then lower which would have provided a suitable substrate for the plants on the continental shelf; the local extinction of *Avicennia* was due to the combination of subsequent sea level rise, increased frostiness, and the disappearance of habitat.

Pollen samples from four localities on the east coast of the North Island were examined, and all contain abundant evidence of recycled pollen from Cretaceous and Cenozoic sediments. Several samples from one locality (Sponge Bay, near Gisborne, about 7 km southeast of the only previously known North Island east coast early Holocene record of *Avicennia*) contain *Avicennia* pollen. Precise paleoclimatic studies were hampered by a massive influx of modern pollen into many of the samples, possibly caused by unrecognised modern cut and fill, recycling of the sediments, and hydrostatic injection of spore- and pollen-bearing water into the soft Holocene sediments under the pressure of the frequent flood conditions. However, radiocarbon dates are internally consistent, suggesting that the last-named is probably the prime cause.

Keywords: *Avicennia marina* var. *resinifera*, Avicenniaceae, mangroves, pollen analysis, recycling, Holocene, radiocarbon dates, paleoclimate, paleoenvironment, hydrostatic injection, Sponge Bay, Poverty Bay, East Cape

INTRODUCTION

While studying postglacial peats and other carbonaceous sediments from test wells drilled for groundwater at Awapuni on the Poverty Bay flats, Mildenhall and Brown (1987) discovered a relatively large number of pollen grains of *Avicennia marina* in one sample. These authors interpreted the presence of *Avicennia* pollen as evidence of warmer climate and lower sea level about 9,800 years ago on the basis of its more southerly location relative to its present distribution (Mildenhall and Brown, 1987; fig. 1). However, the pollen grains were found only at one site, and only in one sample from that site. Was this an isolated record, or did it reflect the fact that only one suitable lithology had so far been sampled? A search for other sites was subsequently undertaken.

In 1989 Head Office, DSIR, allocated funding to the New Zealand Geological Survey to study some aspects of Holocene climate change. The prime objective was to assess the extent and significance of known climate changes between about 10,000–6,000 years BP by study of floristic changes in estuarine sedimentary sequences, which had been preserved mainly as a

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result of tectonic uplift (Ota, Hull and Berryman, 1991; Ota *et al.*, 1992) along the east coast of North Island; and, incidentally, to find *Avicennia* pollen.

A series of samples for pollen analysis was collected from estuarine sedimentary exposures at the mouths of the Whangawehi Stream (Mahia Peninsula), and Owahanga River (both south of the area shown in Fig. 1); and Pakarae River and the beach cliff in Sponge Bay (Fig. 1). Sponge Bay, Owahanga River, and Whangawehi Stream are all south of the previously-documented Holocene *Avicennia* locality at Awapuni, Poverty Bay flats (Mildenhall and Brown, 1987), and Pakarae River is to the north. Samples from all these localities had previously been radiocarbon dated (Ota *et al.*, 1988; 1990; 1992; Ota, Hull and Berryman, 1991; Berryman, Ota and Hull, 1992), and additional radiocarbon samples were collected to obtain better age control of samples from which vegetational changes might be detected from the palynology (Ota, Hull and Berryman, 1991). The prime purpose of this study was to determine the areal and stratigraphic extent of the southward migration of *Avicennia* during the postglacial climatic optimum, first reported by Mildenhall and Brown (1987). This paper summarises the vegetational changes detected in the samples.

Although only one more locality (Sponge Bay) was found to contain *Avicennia* pollen, the palynology and floral significance of all localities examined will be briefly described.

LOCALITIES

The locality details of all samples examined are as follows:

Pakarae River

Pakarae River mouth, about 2 km north of Whangara, coastal East Cape region, grid reference Y17/672817*. Most of the samples were collected from a section, exposed in a cliff cut by the Pakarae River, on the true right river bank, about 600 m upstream of the coast (Fig. 1).

The Pakarae River cliff section exposes tectonically uplifted early Holocene terrestrial, swamp, lagoonal, estuarine, and beach deposits. Wood and shell material associated with the postglacial rise of sea level has been collected from the section and radiocarbon dated. Ages range from 10,360 +/- 130 yrs BP (NZ1357) for organic silts 1.8 m below present day mean sea level, to 6,920 +/- 240 yrs BP (NZ7088) for shells 23.4 m above mean sea level (Ota *et al.*, 1988; 1991). Fig. 2 and Table 1 summarise the stratigraphy and estimates the ages of the palynological samples, based on the published radiocarbon age ranges (Ota, Hull and Berryman, 1991; Berryman, Ota and Hull, 1992).

Sponge Bay

A Poverty Bay beach cliff section, grid reference Y18/498658. Sample f451 comes from 10 m north of samples f445-f450, along the beach and adjacent to a large tree trunk protruding from near the base of the cliff (Fig. 1).

The Sponge Bay beach cliff exposes tectonically uplifted early Holocene estuarine, lagoonal, and swamp deposits. Samples of organic material associated with the postglacial rise of sea level have been collected from the beach cliff and radiocarbon dated. Ages range from 8,200 +/- 87 yrs BP (NZ1439) (Berryman pers. comm., September 1992) and 7,530 +/- 110 yrs BP (NZ6306) near the base (mean sea level) to 6,250 +/- 100 yrs BP (NZ6145) 5.5 m above mean sea level (Ota *et al.*, 1988; 1990; 1992). Fig. 3 and Table 2 summarise the stratigraphy of the site, and estimate the ages of the palynological samples based on the radiocarbon dates.

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* Grid reference for sheet Y17, and subsequent sheets, based on the national thousand metre grid of the 1:50,000 topographical map series INFOMAP 260.

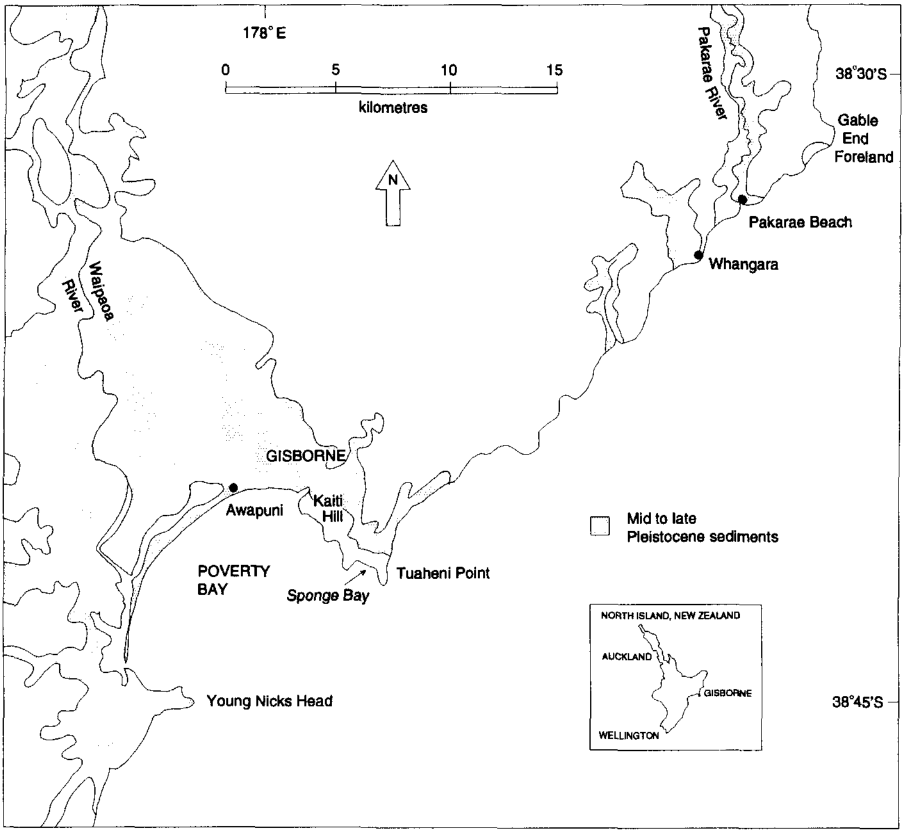

Fig. 1 -Locality diagram showing the distribution of mid to late Pleistocene sediment (stippled), the two localities known to contain Holocene pollen of *Avicennia* (Awapuni and Sponge Bay), and the northern east coast localities mentioned in the text.

Whangawehi Stream

Northeast coast of Mahia Peninsula (Hawke's Bay), approximately 600 m upstream of a bridge, grid reference Y19/375218 (not shown on Fig. 1).

Three samples were collected from marine sediments at this locality, close to previously collected radiocarbon samples (Ota *et al.*, 1988).

Owahanga River

True right bank of Owahanga River (Ota *et al.*, 1990) about 3 km upstream of the coast and opposite a prominent stream valley entering on the true left, grid reference U25/927554. This locality is southeast of Pongaroa, northern Wairarapa, well south of Gisborne and not shown on Fig. 1.

The truncated sequence is composed of about 10 m of estuarine silt and sand containing shell and wood horizons. Some samples were collected close to the sites from which previous radiocarbon samples had been taken (Ota *et al.*, 1988) and other ages in Table 4 are estimates based on the radiocarbon dates. Fig. 4 and Table 4 summarise the stratigraphy of the site.

PALYNOLOGICAL RESULTS

All the pollen samples examined contain spores, pollen, and other organic debris. The localities will be discussed separately, but all localities have certain features in common. All

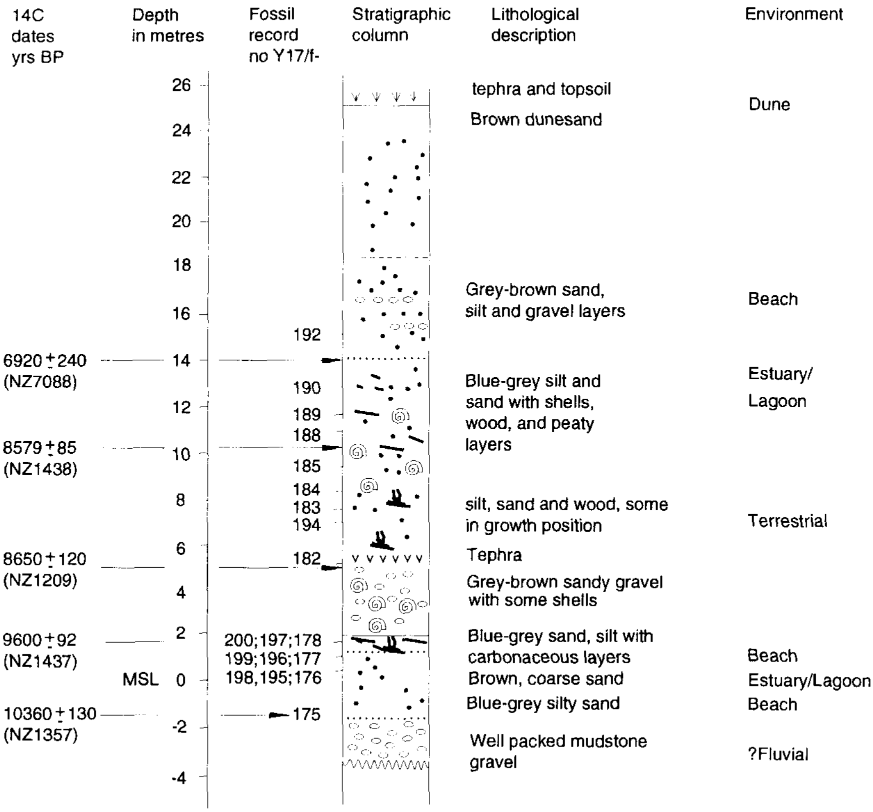

Fig. 2 - Stratigraphic column for Pakarae River based on data provided by L.J. Brown. Depths are given in relation to mean sea level (msl). Selected radiocarbon ages are given in years before present (see also Table 1), calculated in terms of the new half life (5,730 +/- 40 years) and uncorrected for secular effects. NZ numbers refer to the Institute of Geological and Nuclear Sciences Limited radiocarbon laboratory numbers. The fossil record numbers (Y17, Y18, and U25) for this and subsequent columns are based on the metric (INFOMAP 260) system.

samples contained recycled Cretaceous and Cenozoic (including definite Paleocene and Miocene) palynomorphs, including spores, pollen and dinoflagellates, along with presumably recycled charcoal and dark organic debris, including wood, cuticle, and amorphous material. The samples also contained *in situ* organic debris, wood, fibres, vessels, cuticle, stellate hairs, algal remains including *Botryococcus*, fungal spores, sclerotia and hyphae, and charcoal. It is also clear from the vast variation in preservation of the Holocene spores and pollen that they have either been transported to the site of deposition from varying distances or that there is internal recycling of Holocene palynomorphs. The latter explanation is considered to be likely; but others are possible, so the various slight changes in the overall composition of the palynofloras with time are not regarded as significant.

The poor and/or uneven preservation meant that only subjective counting of spores and pollen was possible. The problems of definition included uncertainty of whether dark and poorly preserved "*Cyathea*" spores and podocarp pollen should be included in the count; the impossibility of identifying many of the "ghosts" (spores and pollen that have been either mechanically or biologically degraded so that only a faint translucent outline of the original palynomorph is preserved) that do not have distinctive outlines; and the identification of saccate pollen grains that have lost their sacci. Preservation may differentially favour the

Table 1 – Details of selected radiocarbon dates and all palynological samples from Pakarae River referred to in this paper. Estimated ages of palynological samples are given in brackets. All radiocarbon ages are in relation to Libby half-life and one- or two-standard-deviation counting errors. NZ = Institute of Geological and Nuclear Sciences Limited radiocarbon laboratory number. For stratigraphic position of dated samples see Fig. 2. msl = mean sea level. The fossil record numbers for this and subsequent localities are from sheets Y17, Y18, Y19 and U25, based on the metric (INFOMAP 260) system. The L numbers are slide catalogue numbers for samples held in the Palynology Section, Institute of Geological and Nuclear Sciences Limited

Fossil record no.	Slide no.	Stratigraphic position	(Estimated) 14C age in years BP	Notes
Y17/f175	L14432	1.8 m below msl	10,360 +/- 130 (NZ1357)	peat peat
f176	L14368	0.4 m above msl	(10,000)	estuarine silt
f177	L14369	0.9 m " "	(10,000)	" "
f178	L14370	1.5 m " "	(9,000)	" "
f179		1.6 m " "	9,600 +/- 92 (NZ1437)	" " shell
f181		5.1 m " "	8,650 +/- 120 (NZ1209)	" " shell
f182	L14371	5.4 m " "	(9,000)	" "
f183	L14372	7.6 m " "	(8,000)	" "
f184	L14373	8.4 m " "	(8,000)	" "
f185	L14374	9.4 m " "	(8,000)	" "
f187		10.4 m " "	8,579 +/- 85 (NZ1438)	" " shell
f188	L14375	10.9 m " "	(7,000)	" "
f189	L14376	11.3 m " "	(7,000)	" "
f190	L14377	13.2 m " "	(7,000)	" "
f192	L14378	15.3 m " "	(6,500)	" "
f194	L14379	6.9 m " "	(8,700)	" "
f195	L14380	0.4 m " "	(10,000)	" mud from same level as f176 but 100 m upstream
f196	L14381	0.9 m " "	(10,000)	estuarine mud from same level as f177 but 100 m upstream
f197	L14382	1.5 m " "	(9,000)	estuarine mud from same level as f178 but 100 m upstream
f198	L14383	0.4 m " "	(10,000)	estuarine mud from same level as f176 but 10 m downstream
f199	L14384	0.9 m " "	(10,000)	estuarine mud from same level as f177 but 10 m downstream
f200	L14385	1.5 m " "	(9,000)	estuarine mud from same level as f178 but 10 m downstream

more robust palynomorphs. It is also likely that the ebb and flow of the tide depositing these estuarine sediments may have resorted the palynomorphs, so that an unrepresentative palynoflora was preserved in the first instance.

Most of the samples also contained modern pollen, especially Asteraceae, Poaceae, and *Pinus*, some still with cell contents intact. This could be derived from sample contamination, probably from modern sediment plastered onto the face of the outcrops and incorporated into the sample; non-recognition of modern cut and fill in the sequences of soft estuarine sediments; or, as suggested by A.G. Hull (pers. comm., 1992), hydrostatic injection of spore- and pollen-bearing water into the sediments during floods. Floods are frequent and often

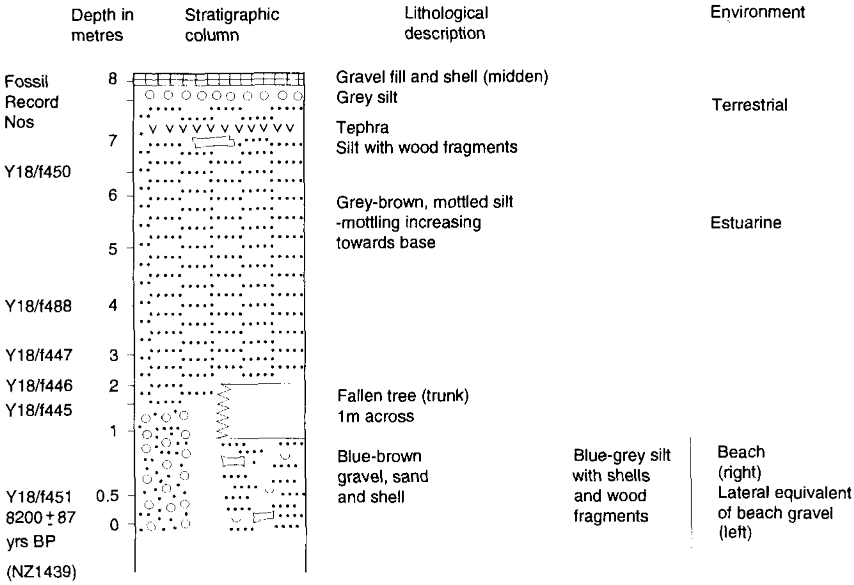

Fig. 3 - Stratigraphic column for Sponge Bay, near Gisborne based on data provided by L.J. Brown. Depths are given in relation to mean sea level (msl). Radiocarbon ages are given in years before present (see also Table 2), calculated in terms of the new half life (5,730 +/- 40 years) and uncorrected for secular effects.

intense, and completely cover the Holocene estuarine sediments that form the river banks adjacent to the river mouths. Detailed palynological investigations of these sediments are therefore unlikely to obtain results truly reflecting the coastal vegetation of the time, even though radiocarbon dates on wood, shells, and carbonaceous sediments are usually internally consistent and apparently not affected by contamination.

Not all samples contained *in situ* dinoflagellates, though some did; even when they were absent the depositional environment is in every case regarded as estuarine from the presence of *Pachysphaera* (a tasmanitid in the heterogenetic green algal family Prasinophyceae), foraminiferal test linings, marine and estuarine shells, the calcareous nature of the enclosing sediments, and interpretation of the stratigraphy and sedimentology.

No attempt was made to identify the recycled dinoflagellates, but identified and recycled spores and pollen are listed in Table 5. Cretaceous and Miocene spores and pollen are indicated; most of the other palynomorphs are probably from the lower Cenozoic.

Table 2 – Details of the radiocarbon dates and palynological samples from Sponge Bay referred to in this paper. For stratigraphic position of dated samples see Fig. 3. See caption to Table 1 for other details

Fossil record no.	Slide no.	Stratigraphic position	(Estimated) 14C age in years BP	Notes
Y18/f445	L14386	2.0 m above msl	(7,500)	Estuarine silt
f446	L14387	2.5 m " "	(7,500)	" "
f447	L14388	3.0 m " "	(7,500)	" "
f448	L14389	4.0 m " "	(7,000)	" "
f450	L14390	6.5 m " "	(6,000)	" "
f451	L14391	0.5 m " "	8,200 +/- 87 (NZ1439) shell	?

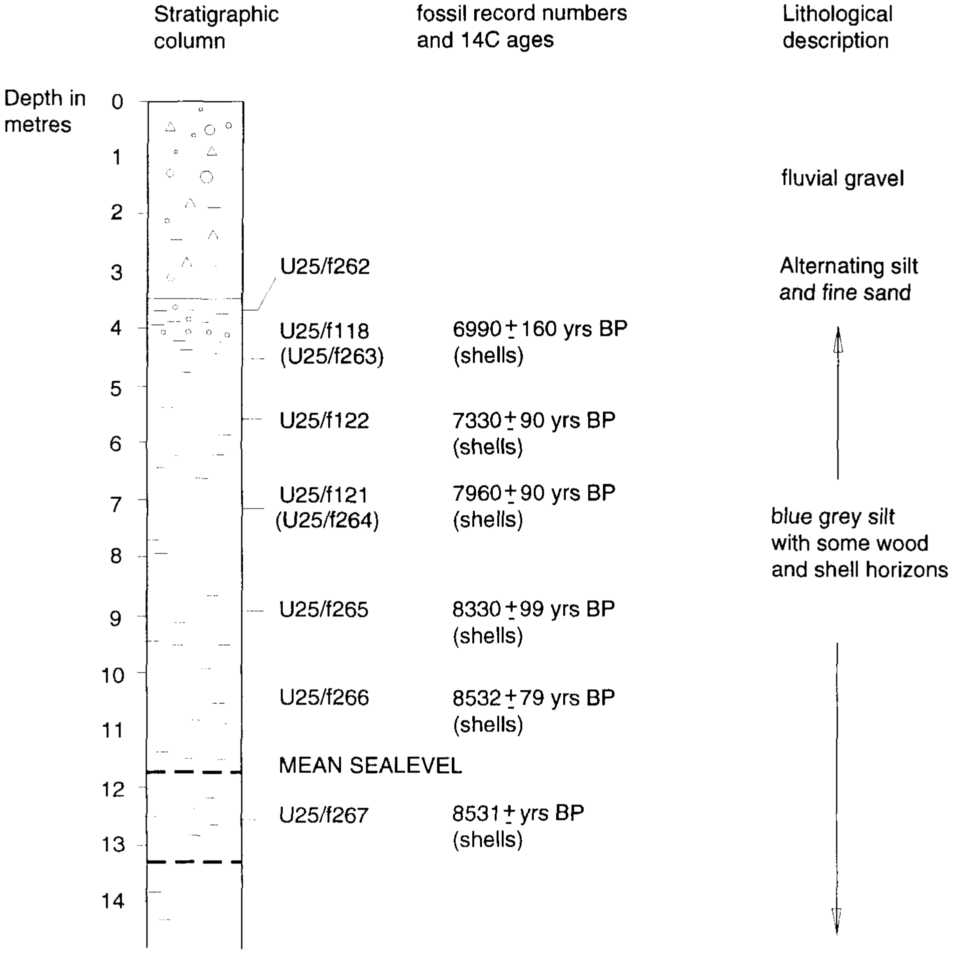

Fig. 4 - Stratigraphic column for Owahanga River based on data provided by L.J. Brown. Depths are given in relation to the top of the section. Samples U25/f262-f264 are sited close to the radiocarbon samples f118, f121, and f122, with f262 sited 1 m below f118. Radiocarbon ages are given in years before present (see also Table 4), calculated in terms of the new half life (5,730 +/- 40 years) and uncorrected for secular effects.

Table 3 – Details of the radiocarbon dates and palynological samples from Whangawehi Stream referred to in this paper. See caption to Table 1 for other details

Fossil record no.	Slide no.	Stratigraphic position	14C age in years BP	Notes
Y19/f53	L14433	?	8,140 +/- 70 (NZ5315; Y19/f24) shell	marine estuarine sandy silt
f54	L14434	?	7,550 +/- 70 (NZ5312; Y19/f21) shell	marine shelly silt
f55	L14435	?	7,100 +/- 70 (NZ7099; Y19/f36) shell	marine shelly sand

Table 4 – Details of the radiocarbon dates and palynological samples from Owahanga River referred to in this paper. For stratigraphic position of dated samples see Fig. 4. See caption to Table 1 for other details

Fossil record no.	Slide no.	Stratigraphic position	(Estimated) 14C age in yrs BP	Notes
U25/f262	L14426	top of estuarine beds	(*c*. 6,500)	alternating shelly silt and fine sand
f263	L14427	same as f118		estuarine silt
f118		*c*.1 m below top estuarine beds	6,990 +/- 160 (NZ6677) shell	" "
f122		*c*.2 m below top estuarine beds	7,330 +/- 90 (NZ6629) shell	" "
f264	L14428	same as f121		" "
f121		*c*.3.5 m below top estuarine beds	7,960 +/- 90 (NZ6683) shell	" "
f265	L14429	5.5 m below top estuarine beds	8,330 +/- 99 (NZ1434) shell	" "
f266	L14430	7 m below top estuarine beds	8,532 +/- 79 (NZ1435) shell	" "
f267	L14431	9.2 m below top estuarine beds	8,531 +/- 95 (NZ1436) shell	" "

Pakarae River

A total of 19 samples was collected from this locality. The samples are thought to span radiocarbon years 10,350 yrs BP to 6,500 yrs BP (Ota, Hull and Berryman, 1991). However, no *Avicennia marina* pollen were found in any of the samples.

There are a number of problems with these samples. Many yielded very few spore and pollen grains and the palynomorphs were very poorly preserved in others (f178, f182, f188, f189, f190, f192, f194, f195, f196, f198, f199, and f200). Some other samples contained abundant modern pollen (*Pinus*, Asteraceae (*Taraxacum* type), Poaceae, *Rumex, Plantago lanceolata*, etc., some with cell contents still preserved), indicating that modern infill, recycled sediments, or spore- and pollen-injected sediments were probably collected, rather than a stratigraphically ordered pollen sequence. These samples have been disregarded in this study, even though they are associated with internally consistent radiocarbon dates. They were f176 (dominated by grass and sedge pollen, some with preserved cell contents), f177 (dominated by grass and Cretaceous/Cenozoic recycled pollen), f178, f182, f195, f196, f197 (dominated by Asteraceae (*Taraxacum* type) and grass pollen), f198, f199, and f200. The mangrove is insect pollinated, so its pollen is always under-represented (Muller 1964) and difficult to find, since it does not disperse away from the immediate vicinity of the parent trees. (Macphail and McQueen (1983) regard *Avicennia* pollen as well- to over- represented in Pleistocene and Recent deposits, but do not give reasons for this conclusion). Therefore, sparsely fossiliferous samples such as these are inadequate for determining whether *Avicennia* pollen should be present or not; it has not formed more than 9% of total pollen in any East Coast sample, and in the Firth of Thames only 20% mangrove pollen recovery was reported by Pocknall *et al.* (1989) from samples that must have been almost beneath the living trees. The modern infill sediments are too young to contain *Avicennia*.

This leaves only four samples f175, f183, f184, and f185 judged to contain apparently *in situ* palynomorphs. These four samples are all dominated by podocarp pollen, primarily *Dacrydium cupressinum, Podocarpus totara, Prumnopitys taxifolia*, and *Dacrycarpus dacrydioides*, plus varying amounts of Cyperaceae and *Leptospermum/Kunzea*. *Dacrydium cupressinum* dominates two samples (f183, f185). The total assemblages are spore-dominated, with *Cyathea* spores forming 50% or more of each assemblage. The palynofloras suggest

Table 5 – List of recycled spores and pollen found in estuarine sediments sampled on the east coast of the North Island

SPORES
Baculatisporites, Cretaceous
Ceratosporites, possibly Cretaceous
Cicatricosisporites, Cretaceous
?*Cingutriletes*
Contignisporites, Cretaceous
Cyathidites spp., includes Cretaceous
?*Echinosporis*
Foveosporites lacunosus Partridge
Gleicheniidites circinidites (Cookson), possibly Cretaceous
Ischyosporites
?*Leptolepidites*, Cretaceous
Lycopodiumsporites spp., includes Cretaceous
Lycopodiumsporites austroclavatidites (Cookson), possibly Cretaceous
Osmundaceae (including *Osmundacidites wellmanii* Couper), probably Cretaceous
?*Perotriletes*, Cretaceous
Polypodiaceoisporites spp.
Polypodiisporites spp.
Polypodiisporites inangahuensis (Couper)
Polypodiisporites minimus (Couper)
Polypodiisporites variscabratus Mildenhall & Pocknall
Rugulatisporites spp.
?*Rugulatisporites cowrensis* (Martin)
Rugulatisporites trophus Partridge
Stereisporites (*Sphagnum*-like spores), probably Cretaceous
Triletes (unidentified trilete spores), includes Cretaceous

POLLEN
Araucariacites australis Cookson
?*Classopollis*, Cretaceous
?*Cycadopites*, possibly Cretaceous
Phyllocladidites mawsonii (Cookson), Cretaceous and/or Cenozoic
Podocarpidites spp., possibly includes Cretaceous
Trichotomosulcites subgranulatus Couper, Cretaceous
Beaupreaidites elegansiformis Cookson
Cranwellia striata (Couper)
Cupanieidites orthoteichus Cookson and Pike
Haloragacidites harrisii (Couper), frequent
Malvacipollis
Monosulcites otagoensis Couper
Nothofagidites emarcidus (Cookson)
?*Nothofagidites kaitangataensis* (Couper), Cretaceous
Nothofagidites lachlaniae (Couper), frequent
Nothofagidites matauraensis (Couper), very common
Nothofagidites spinosus (Couper)
Nothofagidites waipawaensis (Couper)
Nyssapollenites endobalteus (McIntyre), probably Miocene
Peninsulapollis gillii (Cookson)
Polycolporopollenites esobalteus (McIntyre)
Proteacidites spp.
Proteacidites pseudomoides Stover
Proteacidites subscabratus Couper
Rhoipites alveolatus (Couper)
Rubipollis oblatus (Pocknall & Mildenhall), definite Miocene
Tricolpites spp.
Triorites minor Couper, possibly Cretaceous

derivation from a lowland podocarp forest, little different from that growing in the area at the present day. Since this locality is to the north of both Sponge Bay (see below) and Awapuni (Mildenhall & Brown 1987), *Avicennia* might be expected to appear in the estuarine sediments of the four palynologically richest samples, ranging in estimated radiocarbon age from 10,500 yrs BP to 8,000 yrs BP. Possibly the sediments at the upper end of this time range were unsuitable; or *Avicennia* had not migrated this far south by 10,500 years; or the narrow coastal fringe containing mangrove was not represented in the upper three samples, radiocarbon dated at about 8,600 yrs BP (Fig. 2), if the mangrove grew at the time either seaward or landward of the site examined. The growth of mangrove is affected by, for example, sedimentation rates, exposure to open coasts, and other factors (Mildenhall and Brown, 1987; Pocknall, Gregory and Grieg, 1989), and it could well have been restricted in distribution during the early to mid Pleistocene.

Sponge Bay

A total of six samples was collected from this locality. They span radiocarbon years 8,200 yrs BP to 6,000 yrs BP (Fig. 3; Ota *et al.*, 1988; 1990). *Avicennia* pollen was found in all samples, except f445 which was dominated by grass pollen, some of which still had cell contents preserved, and is regarded as being a modern infill sediment, or a spore and pollen injected sediment, and probably outside the early Holocene time range of *Avicennia* in the area. This sample also had evidence of massive Cretaceous/Cenozoic recycling.

Sample f451 contained only sparse *in situ* and recycled spores and pollen, and is not considered further. It contained a possible, poorly preserved, *Avicennia* pollen grain.

The other four samples were all dominated by podocarp pollen, primarily *Podocarpus* and *Prumnopitys*, with lesser amounts of *Dacrydium cupressinum* and *Dacrycarpus dacrydioides*. The only other pollen types to reach more than 3% of total pollen were *Ascarina lucida*, *Dodonaea viscosa*, and *Nothofagus fusca* type (pollen of *N. fusca, N. truncata* and *N. solandri* are indistinguishable). Spores formed a much lower percentage in these samples than in any other sequence of samples examined during this study. *Cyathea* spores accounted for between 16% and 45% of the total palynoflora, but some of these may well have been recycled from Cretaceous or Cenozoic sediments. Otherwise the assemblage was identical to that from the Pakarae River, and represented a lowland podocarp forest growing in warm, moist, relatively frost-free temperate conditions (McGlone, 1983; 1985). The presence of *Avicennia marina* indicates that the temperatures in the area must have been at least one degree higher than now, and that frosts were less frequent than they are now (Mildenhall and Brown, 1987). This locality extends the age range of *Avicennia* on the east coast from 9,840±190 yrs BP (Mildenhall and Brown, 1987) at Awapuni on the Poverty Bay Flats, about 2 km north of Sponge Bay, to about 6,000 yrs BP at Sponge Bay.

The problem with interpreting this as a record of living *Avicennia* at Sponge Bay in the Holocene is that the species has not been found elsewhere during this time interval, and, because recycling within the Holocene sediments is common, it is possible that all the grains sampled here are recycled from older material. In spite of this, the radiocarbon dates and the pollen appear to be accurate records, therefore, it is assumed from the evidence that *Avicennia* was in the area at 6,000–7,500 yrs BP and before. It is also assumed that *Avicennia* lived a few kilometres to the northwest in Awapuni about 9,800 years ago and that it had died out there before 7,500 years ago. Any potential mangrove seedpods migrating to and developing in the Awapuni area at the present day would have to travel much further south around Tuaheni Point and Sponge Bay to get back to this locality from northern sites. Even during the early to mid Holocene, when Tuaheni Point and Kaiti Hill were islands, the migrating mangrove seedpods would have to travel further south around Cenozoic sediments to get to Awapuni from parent trees established further north.

Whangawehi Stream

Three samples were collected from Whangawehi Stream. The radiocarbon dates from this locality ranged between 8,140±70 yrs BP to 7,100±70 yrs BP (Ota *et al.*, 1988). No *Avicennia* pollen was found in any of the samples.

All three samples contained pollen assemblages dominated by the same podocarp pollen as in previous samples. Sample f54 was dominated by *Dacrydium cupressinum*, and the other two by *Podocarpus* and *Prumnopitys*. Other pollen types forming more than 3% of total pollen included *Alectryon, Ascarina lucida*, Cyperaceae, *Dodonaea viscosa, Leptospermum/ Kunzea*, and *Nothofagus fusca* type. The spores were overwhelmingly dominated by *Cyathea* which formed between 57% and 75% of total spores and pollen. The palynoflora was typical of that derived from a podocarp forest growing in a moist, temperate, relatively frost-free coastal environment.

Since *Avicennia* was living only 55 km to the north in Sponge Bay during the period of deposition of these samples, its absence here may be either because the environment was unsuitable for mangrove (unlikely in view of the type of sediments examined, unless the sedimentation rate was too high); or because the mangroves lived either seaward or landward of the site examined; or because it had not been able to reach this far south since the beginning of the Holocene.

Owahanga River

Six samples were collected from this locality. Sample f266 contained a sparse, poorly preserved palynoflora and is not considered further. The samples from this locality span radiocarbon years 8,531±95 yrs BP (K. R. Berryman pers. comm., September 1992) to 6,990±160 yrs BP (Ota *et al.*, 1990). No *Avicennia* pollen was found in any of them.

The five productive samples are indistinguishable from those described from Sponge Bay and Whangawehi Stream. All were dominated by podocarp pollen; *Dacrydium cupressinum* was dominant in f262 and co-dominant with *Podocarpus* and *Prumnopitys* in f263, and *Podocarpus* and *Prumnopitys* were dominant in the others. The only other pollen types to form more than 2% of total pollen were *Dacrycarpus dacrydioides, Dodonaea viscosa*, and *Nothofagus fusca* type. *Cyathea* spores overwhelmingly dominated the total palynoflora, forming between 57% and 74% of the total count. The palynoflora was typical of a podocarp forest growing in a moist, warm, and relatively frost-free lowland coastal environment. *Avicennia* could have lived there if it had been able to migrate this far south during the Holocene.

CONCLUSIONS

1. Mangroves grew in the Poverty Bay – East Cape region during the early to mid Holocene, from approximately 9,800 to about 6,000 years BP, and have been recorded at two localities. In samples from suitable sediments with adequately preserved palynomorphs, the presence of *Avicennia* pollen could provide a good indicator of past shorelines, salinity, paleoenvironments, and temperature, and provide a good biostratigraphic marker. There is still no reason to suppose that mangroves did not extend down the East Coast even further south than the two localities so far discovered.
2. Temperatures must have been at least one degree warmer than at the present day, and conditions were more frost-free, for mangroves to survive (Mildenhall and Brown, 1987). Rainfall and humidity were probably higher since the more cloudy the winter skies, the lower the probability of frosts.
3. Sea levels must have been lower than now to enable the mangrove to migrate around East Cape, and other east coast promontories, on sediments suitable for its continued expansion and survival. In New Zealand, the Postglacial sea level rise reached the present day level about 6,500 years ago. Between 10,000 and 6,500 years ago sea level rose about 30 m, with possible fluctuations, related to climate change, about 7,000, 8,500, and 9,800 years ago (Gibb 1986). This suggests that *Avicennia* had opportunities for migration around East Cape. Tectonic activity since the end of the Last Glaciation has caused uplift in some, if not all, of the study areas (Ota *et al.* 1988; 1990; 1992; Ota, Hull and Berryman, 1991; Berryman, Ota and Hull, 1992).

4. The disappearance of *Avicennia* from the east coast has been the result of a rise in sea level causing loss of suitable habitat, combined with increased frostiness over the last 6,000 years providing a climate unsuitable for mangrove survival.
5. Massive recycling from Cretaceous and Cenozoic sediments, modern reworking of the estuarine sediments, and modern spore and pollen injection into Holocene sediments in the area studied have all meant that it is difficult to place a paleoenvironmental and paleoclimatic interpretation on the pollen assemblages from the sediments sampled. Such interpretations are possible only when key taxa that are unlikely to be recycled or injected, like *Avicennia*, are present. This contamination, its origin, and its likely occurrence in the past, indicate that paleoecological interpretations of estuarine sediments are subject to considerable sources of error.

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