Early Maori settlement impacts in northern coastal Taranaki, New Zealand

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Abstract: Pollen and charcoal analyses of sediments from northern coastal Taranaki, New Zealand, show that Maori settlement impacts on the vegetation began with the burning of tall coastal forest in the mid-17th century. Forest was replaced with a fern-shrubland, and small wetlands expanded with changing hydrological conditions. This forest clearance was much later than in most regions of the country, where major forest disturbance and clearance began between AD 1200 and AD 1400. However, Maori were known to be using the forested coastal Taranaki landscape from at least AD 1300 to hunt the now extinct moa, and to collect shellfish, but neither of these activities necessarily required forest clearance or permanent settlement. Preserved rat-gnawed seeds in the wetland deposits provide evidence for the presence of the introduced kiore (Polynesian rat, *Rattus exulans*) in coastal Taranaki from about AD 1200, significantly before forest clearance or permanent human settlement. Although kiore were present in the coastal forests for as much as 400 years before forest clearance, the pollen records do not show any changes in forest composition during this time.

Keywords: *Corynocarpus laevigatus*; deforestation; human settlement; karaka; kiore; Maori; pollen; *Rattus exulans*; seed predation; North Taranaki.

Introduction

Before Maori permanently settled New Zealand, between 85 and 90% of the country's land area was covered in dense forest (McGlone, 1989) and natural fire was rare (Ogden *et al*., 1998). Estimates for the onset of permanent human settlement in New Zealand, based on radiocarbon determinations of the earliest archaeological material, suggest it began about AD 1200–1300 (Anderson, 1991; Higham *et al.*, 1999). For the same period, there are extensive records for the decline of moa (Anderson, 1984; Holdaway and Jacomb, 2000), seals (Smith, 1989), and numerous smaller birds (Cassels, 1984; Worthy and Holdaway, 2002) resulting from hunting and gathering by Maori. Most pollen and charcoal records from throughout the drier regions of the country show deforestation by anthropogenic fire at this time (McGlone and Wilmshurst, 1999). This transformation of a landscape rarely exposed to natural fires (Wilmshurst *et al.*, 1997; Ogden *et al*., 1998) reduced the forest cover in New Zealand by half (Masters *et al*., 1957) and replaced it with bracken (*Pteridium esculentum*) fern-shrubland and grassland (McGlone and Wilmshurst, 1999; McGlone, 2001). Fire was used repeatedly to prevent forest regeneration and encourage bracken for a variety of reasons, one of which was the provision of starchy rhizomes, an important food for Maori (McGlone, 1983). Vegetation records rarely show signs of forest recovery after these initial fires (McGlone and Basher, 1995).

Several pollen diagrams have been analysed from the Taranaki region, including some from coastal sites south of the Mt Taranaki volcano (Bussell, 1988), and on Mt Taranaki (McGlone *et al*., 1988; Lees and Neall, 1993). Although the dating is generally poorly resolved, these records all indicate a relatively late (i.e. younger than 400 years B.P.) deforestation sequence compared with the drier eastern regions of New Zealand (*c.* 800–600 years B.P., McGlone and Wilmshurst, 1999). This study provides a record of the pre-deforestation vegetation in northern coastal Taranaki, identifies human-related settlement impacts on this local environment, and explores how early Maori settlement proceeded in wet, dense coastal forests. Pollen analyses of several small linked catchments are used as replicates, to identify the pattern of local vegetation change. This pattern is compared with regional pollen records from other sites in Taranaki.

Study area

North Taranaki

The study region lies in a coastal strip along northern Taranaki that consists of late Quaternary uplifted marine terraces overlain by terrestrial cover beds and accumulated coastal sands (Neall, 1982). Coastal cliffs are up to 60 m high. Coastal north Taranaki has a mild, moist oceanic climate, with mean annual temperatures of 13-14ºC (February average, 17ºC; July 9ºC), and well-distributed mean annual rainfall of *c*. 2000 mm. Air frost is uncommon, occurring on average twice a year, and snow and hail are rare (Thompson, 1981).

The study areas are all drained wetlands, currently in exotic pasture grazed by dairy cattle. Although groves of trees were present among "fertile fern-hills" in coastal Taranaki in the 1840s (Dieffenbach 1843), there is little forest remaining today. In the 1840s the bush edge was about 2–3 km from the coast (Phillips *et al*., 2001, pp. 108–109) which is closer than in the drier southern coastal regions from Sugar Loaf point to Cape Egmont (5–6 km inland; Dieffenbach, 1843) and from Warea to Opunake (*c*. 7–10 km inland; Mathews, 1905). Currently the bush edge in northern Taranaki lies some 5–6 km inland.

The Taranaki wetlands analysed in this study were of cultural significance to the local Maori; the preservation properties of peat were well known, and this is reflected in their use as storage areas for *taonga* (treasure/property). Many treasures were buried at times of warfare and retreat, consigning them to the protection of *Hine-i-te-huhi*, the Maiden of the Swamps, for later retrieval (Keenan, 2002; Phillips *et al*., 2002). Over the years a selection of artefacts dating from before European contact have been retrieved from the northern Taranaki wetlands, including elaborate carvings and more-utilitarian goods such as *ko* (digging sticks), *patu aruhe* (fernroot beaters), *kumete* (bowls), *ketu* (weeders), *kaheru* (wooden spades), wooden stakes and a composite adze haft (Day, 2001; Johns, 2001). These have been conserved at the Conservation Laboratory, Anthropology Department, University of Auckland, and subsequently returned to Puke Ariki (Information and Heritage Centre for Taranaki) under a Memorandum of Understanding with Ngati Mutunga.

Mimi site

The Mimi site is a narrow drained wetland between low hills, about 25 m above sea level and 1.5 km east of the Mimi River mouth, which drains into the Tasman Sea (Grid reference NZMS sheet Q19: 263600E; 624837N) (Fig. 1). A small stream drains south through the wetland into the Mimi River. The site began to be farmed in the early 1900s and was partly drained in the 1950s (Jim Phillips, *pers. comm.,* landowner, North

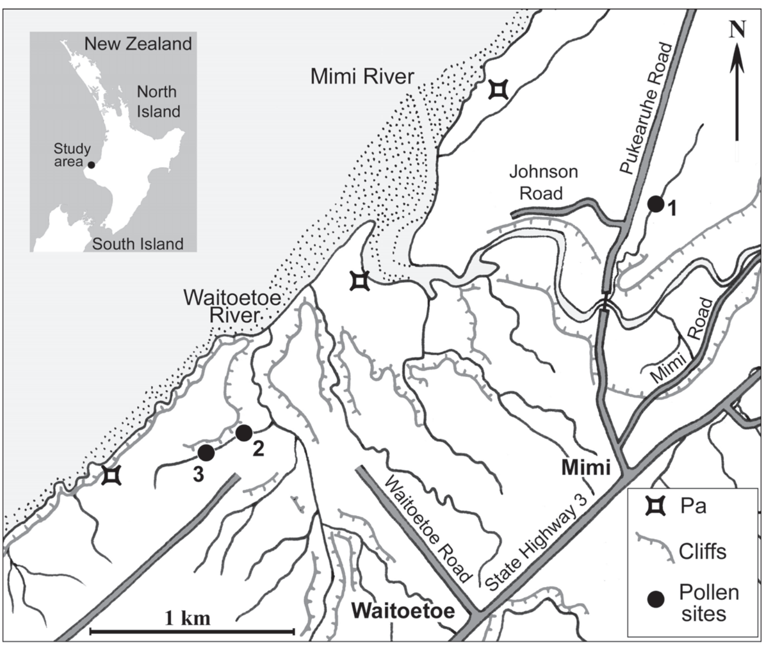

Figure 1. Map of northern coastal Taranaki showing (1) Mimi, (2) Waitoetoe-A, and (3) Waitoetoe-B coring sites.

Taranaki, N.Z.). Numerous archaeological artefacts, including wooden domestic and agricultural implements, have been found preserved in this wetland (Johns, 2003). A section of peat in one of the drainage ditches was sampled (lab i.d. X00/22). An additional sample of seeds was taken for radiocarbon dating from another exposed drainage ditch (lab i.d. X00/31) in the same wetland, about 90 m from X00/22, which was cross-correlated with the X00/22 section by a distinctive basal sandy-tephra layer.

Waitoetoe sites

Two peat sections, Waitoetoe-A (lab i.d. X01/9: Grid reference NZMS map sheet Q19: 263390E; 624715N) and Waitoetoe-B (lab i.d. X01/11: Grid reference NZMS map sheet Q19: 263395E; 624720N), were recovered from a drainage ditch that had been dug along the length of a wetland at the base of a narrow valley with low hills either side (Fig. 1). The valley would have been the most coastal tributary of the Waitoetoe River, which drains into the Tasman Sea. The coring sites are less than 0.5 km from the coast. The wetland is drained, covered in pasture and grazed by cattle. Waitoetoe-A was 90 m upstream from Waitoetoe-B; the latter peat deposit was deeper (>3 m) than Waitoetoe-A (<1 m) and directly below a small remnant of coastal forest containing *Metrosideros* spp., *Melicytus ramiflorus, Melicope ternata, Dicksonia squarrosa, Macropiper excelsum*, *Griselinia lucida*, *Geniostoma rupestre* var. *ligustrifolium*, *Corynocarpus laevigatus*, *Fuchsia excorticata*, *Dysoxylum spectabile*, *Brachyglottis repanda*, *Ripogonum scandens*, and *Coprosma* spp. The understorey was virtually bare in the remnant due to cattle grazing and trampling. A *taurapa* (canoe stern) and *kakau* (adze) handle have been found preserved in the Waitoetoe peats (Phillips *et al*., 2001). Many pieces of old wood, forced out by shrinking peat, were present on the peat surface of all the drained wetlands in this study.

Methods

The peat faces of Mimi and Waitoetoe-A ditches were sampled by clearing back the peat surface, pushing a 15-cm-diameter plastic drainpipe section into the peat face, and cutting it free. Sampled sections were described in the field, covered with plastic wrap, then stored at 4°C and subsampled in the laboratory. Waitoetoe-B was sampled *in situ* at 5-cm intervals from the surface down to the water level in the drain.

Pollen and sediment analyses

Subsamples (1–2 cm^3) from the sediment profile were prepared for pollen analysis using standard procedures (hot 10% KOH, 40% HF and acetolysis) as outlined in Moore *et al.* (1991). Pollen counts were continued until a dryland pollen sum of at least 250 grains was reached. Percentage calculations are based on dryland pollen types (including *Pteridium esculentum* spores). The area of microscopic charcoal fragments was quantified using the point count method of Clark (1982), and expressed as a percentage of the pollen sum to avoid spurious fluctuations resulting from changing accumulation rates. Pollen results were calculated and drafted using TILIA and TILIA.GRAPH (Grimm, 1992). Loss on ignition (LOI) was measured for fresh peat samples at 5-cm intervals. Samples were dried at 90°C for 24 hours, weighed, and then ashed in a muffle furnace for 4 hours at 550°C (Bengtsson and Enell, 1986). The sample weight loss after combustion is expressed as a percentage of the dry weight and reflects the organic content of the sediments.

Radiocarbon dating

Bulk peat and selected seeds and plant fragments were submitted for Liquid Scintillation and Accelerator Mass Spectrometry (AMS) radiocarbon dating (Table 1) at the Waikato Radiocarbon Dating Laboratory, University of Waikato, New Zealand. These were pretreated with routine acid-base-acid (ABA) methods, rinsed and dried. Radiocarbon determinations were calibrated using OxCal v3.6 (Bronk Ramsey, 1995, 2001). Radiocarbon results less than 1000 yr B.P. in age were calibrated using the Southern Hemisphere curve (Hogg *et al*., *in press*), while those greater than 1000 B.P. were calibrated using the INTCAL98 curve (Stuiver *et al*., 1998) with an offset of 27 ± 5 yr applied to take account of the Southern Hemisphere offset as measured by McCormac *et al*. (1998).

Results

Descriptions of core stratigraphies are given in Tables 2–4. Pollen diagrams are presented in Figs. 2–4, and to assist with their discussion, the diagrams have been zoned according to major changes in pollen composition. The dominant pollen types in these zones are described in Table 5, and associated radiocarbon dates given in Table 1.

Discussion

Pre-deforestation vegetation

The absence of charcoal in the pre-deforestation era (zone 1 in the Mimi and Waitoetoe-B profiles) indicates that fire was not common before permanent human settlement in the area. Before deforestation, the Mimi and Waitoetoe sites were covered by a coastal forest

Table 1. Results of radiocarbon dating from Mimi and Waitoetoe wetlands. (AMS = Accelerator Mass Spectrometry, LS = Liquid Scintillation radiocarbon dating method).

Core	Depth (cm)	Radiocarbon dating lab identifier	Conventioal age yr B.P.	Calibrated yr AD 68% CI	Material dated
Mimi (X00/22)	70	Wk-10522 (AMS)	modern	Contaminated	Monocot stem remains sieved from peat matrix, all charcoal removed
Mimi (X00/22)	94	Wk-10523 (AMS)	218 ± 57	AD 1645-1705 (20.6%) AD 1720-1810 (37.8%) AD 1870-1880 (1.4%) AD 1930… (8.3%) (Cal. date out of range)	Monocot stem remains and *Sphagnum* leaves sieved from peat matrix, all charcoal removed
Mimi (X00/22)	*Ex situ*	Wk-8548 (AMS)	780 ± 70	AD 1220-1305 (57.4%) AD 1360-1385 (10.8%)	Kiore-gnawed *Prumnopitys ferruginea* seed collected from basal sandy tephra layer in ditch tailings
Mimi (X00/31) 90 m from X00/22	33 (equivalent depth in X00/22 112 cm)	Wk-8990 (AMS)	1026 ± 63	AD 980-1065 (41.9%) AD 1085-1125 (17.0%) AD 1135-1160 (9.3%)	*Prumnopitys ferruginea* seed on top of basal sandy tephra layer
Mimi (X00/31) of basal sandy tephra	50 (equivalent depth in X00/22 120 cm)	Wk-8991 (AMS)	754 ± 65	AD 1230-1250 (9.7%) AD 1265-1320 (38.2%) AD 1350-1385 (20.3%)	Kiore-gnawed *Prumnopitys ferruginea* seed at base of sandy tephra layer
Mimi (X00/31)	125–130 (equivalent depth in X00/22 112 120 cm)	Wk-11423 (LS)	3711 ± 60	2195-2175 BC (3.7%) 2145-1975 BC (64.5%)	Bulk peat from basal sandy tephra layer
Waitoetoe-A X01/9	80	Wk-11795 (AMS)	342 ± 51	AD 1500-1595 (52.5%) AD 1615-1645 (15.7%)	*Potomogeton pectinatus* and Cyperaceae seeds
Waitoetoe-B X01/11	10	Wk-11796 (AMS)	222 ± 48	AD 1645-1700 (19.8%) AD 1725-1810 (41.8%) AD 1940... (6.5%) (Cal. date out of range)	Plant fragments sieved from peat matrix
Waitoetoe-B X01/11	85	Wk-11797 (AMS)	Modern (127 ± 46)	Contaminated	Plant fragments sieved from peat matrix
Waitoetoe-B	40	Wk-11426 (LS)	1822 ± 52	AD 130-200 (27.7%) AD 205-260 (26.9%) AD 280-290 (3.1%) AD 295-325 (10.5%)	Bulk peat top of upper sandy layer
Waitoetoe-B	50–65	Wk- 11425 (LS)	2310 ± 56	400-350 BC (31.8%) 295-230 BC (32.7%) 220-205 BC (3.7%)	Bulk peat between sandy layers

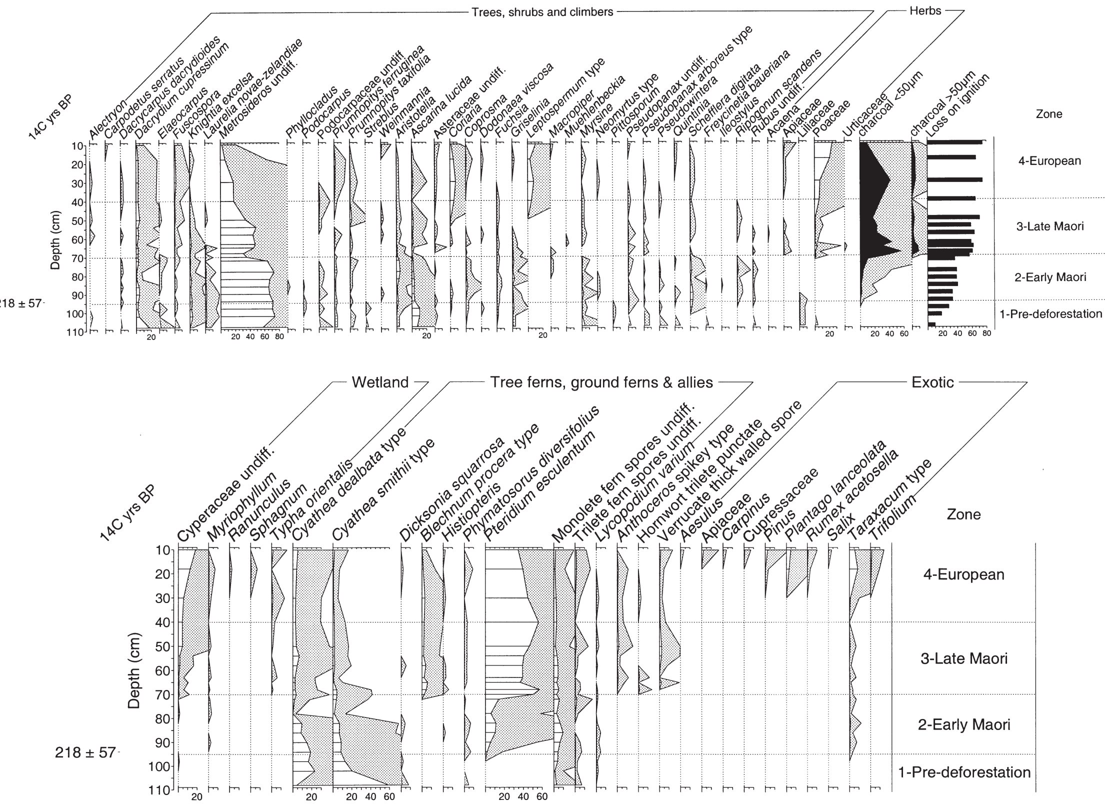

Figure 2. Percentage pollen diagram for Mimi site. Shaded curve represents ×10 exaggeration.

Table 2. Sediment stratigraphy, Mimi (Phillips' Farm) X00/22.

Depth (cm)	Description
0–20	Poorly humified peat with decomposed *Sphagnum* moss (10–15 cm) and grass roots in surface 8 cm
20–70	Coarsely fibrous, reddish brown, humified peat
70–100	Finely fibrous, humified silty peat
100–105	Transition to light brown peat soil
105–110	Mottled light brown clay soil
110–112	Dark brown soil
112–120	Coarse sandy tephra with a sharp lower boundary on Tertiary mudstone contains numerous *Prumnopitys ferruginea*, *Vitex lucens* and *Elaeocarpus* sp. seeds

Table 3. Sediment stratigraphy, Waitoetoe-A (Zimmerman's Farm X01/9).

Depth (cm)	Description
0–18	Organic silty soil with some grass roots
18–20	Coarse peat with visible plant remains
20–43	Reddish dark brown peat with red woody and fibrous remains, and visible charcoal
43–61	Yellow-brown peat with visible plant remains
61–78	Sandy peat layer containing coarse fibrous remains and Cyperaceous stems
78–79	Finely fibrous mat in direct contact with papa (Tertiary mudstone)
79+	Basal papa with stones

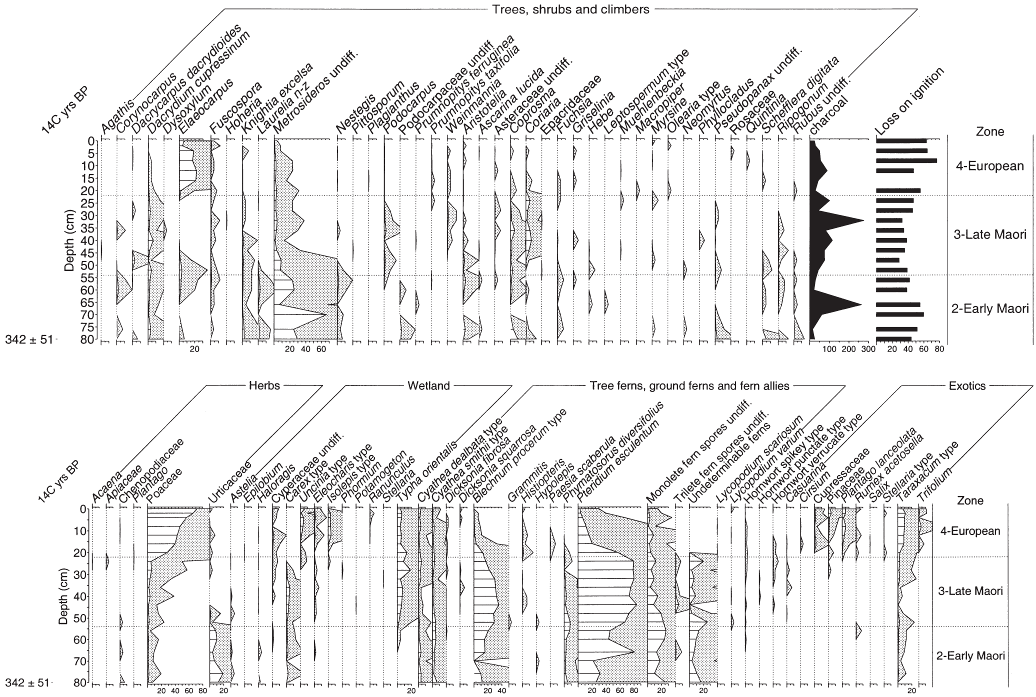

Figure 3. Percentage pollen diagram for Waitoetoe-A site. Shaded curve represents ×10 exaggeration.

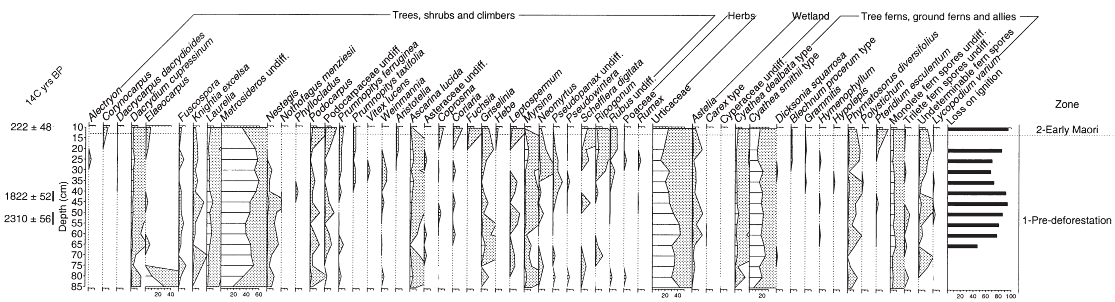

Figure 4. Percentage pollen diagram for Waitoetoe-B site. Shading indicates ×10 exaggeration.

Table 4. Sediment stratigraphy, Waitoetoe-B (Zimmerman's Farm X01/11).

Depth (cm)	Description
0	Grass-covered surface
0–14	Black soil and grass roots
14–23	Pulpy orange-brown woody peat
23–40	Reddish brown, fibrous, soily peat with small pieces of wood
40–52	Sandy layer with organics and wood. Intact seeds of *Prumnopitys ferruginea*, *Elaeocarpus* sp., and *Vitex lucens*
52–65	Reddish brown, fibrous, soily peat with small pieces of wood and coarse plant stems at base. Intact seeds of *Prumnopitys ferruginea*, *Elaeocarpus* sp., and *Vitex lucens*
65–89	Coarse sandy layer with some organics
89+	Reddish brown peat with wood and organic debris

Table 5. Summary of dominant pollen types in each zone of the Mimi and Waitoetoe cores.

Zone	X00/22 Mimi	X01/9 Waitoetoe-A	X01/11 Waitoetoe-B
1: Pre-deforestation	110–95 cm: Zone dominated by *Metrosideros* with lesser amounts of *Dacrydium cupressinum*, *Knightia excelsa*, *Ascarina lucida*, *Cyathea dealbata* and *C. smithii* types. Other tree and shrub pollen types at low percentages. LOI[1] is relatively low and averages 16%, but shows an increasing trend towards zone 2.	Pre-deforestation era not recorded in profile	85-10 cm: Zone 1 represents most of the pollen profile, and is dominated by *Metrosideros* type pollen and *Cyathea smithii* spores. It also contains low levels of pollen from other trees and shrubs including *Laurelia*, *Ascarina lucida* and *Nestegis*. Urticaceae pollen is abundant. Charcoal is absent. LOI averages 79.1%
2: Early Maori	95–70 cm: *Metrosideros* remains dominant pollen type, with minor amounts of *Aristotelia*, *Schefflera digitata*, and many other trees and shrubs. *Cyathea dealbata* and *C. smithii* types decline, as does *Ascarina lucida*. Charcoal, *Pteridium esculentum* and *Taraxacum* make first appearance. LOI averages 37% and remains stable.	80–55 cm: *Metrosideros* is dominant, with minor amounts of other trees and shrubs including *Dacrydium cupressinum*, *Laurelia*, *Knightia excelsa*, *Aristotelia*, and *Schefflera digitata*. Urticaceae pollen is abundant. There are traces of Poaceae, low levels of *Carex*. *Pteridium esculentum* and ground ferns are abundant. *Corynocarpus laevigatus* occurs at low values. Charcoal particles present. LOI values average 47.5%	10–0 cm: *Metrosideros* declines by about 20% but remains dominant. There is an increase or sudden appearance at low levels of *Pteridium esculentum*, *Corynocarpus laevigatus*, *Fuchsia*, *Schefflera digitata*, *Coriaria*, *Coprosma* and *Leptospermum*. Traces of charcoal recorded. LOI averages 88.04% (no values from lower sandy layer)
3: Late Maori	70–40 cm: *Metrosideros* declines sharply, coinciding with an increase in large and small charcoal, *Pteridium* (no values from lower sandy layer) *esculentum*, ground ferns, *Blechnum procerum* type, hornwort spores and low levels of Poaceae, *Typha orientalis* and Cyperaceae. LOI averages 68% and increases towards the surface.	55–20 cm: *Metrosideros* declines sharply to 5%, as do *Laurelia* and Urticaceae, which coincides with an increase in charcoal, *Pteridium esculentum*, ground ferns, *Blechnum procerum* type, *Weinmannia*, *Coprosma*, *Coriaria*, Poaceae, *Carex*, *T. orientalis* and hornwort spores. *Corynocarpus laevigatus* occurs at low values. LOI average drops to 39.5%	Late Maori period not recorded in profile
4: European	40–0 cm: Further decline in *Metrosideros* (to <2%). *Pteridium esculentum*, *Blechnum procerum*, and charcoal decline towards surface. *Leptospermum*, *Coriaria*, Poaceae, Cyperaceae all increase. *Sphagnum* spores occur, and introduced taxa are recorded for the first time, including Pinaceae, *Trifolium*, *Plantago lanceolata* and *Rumex*. LOI is highest in this zone, and averages 73.5%	20–0 cm: *Metrosideros* remains at less than 5% and *Coprosma*, *Coriaria*, *Pteridium esculentum*, tree ferns, ground ferns, *Blechnum procerum* and charcoal decline towards surface. *Elaeocarpus,* grasses and sedges increase; as do the first recorded exotic taxa including Pinaceae, *Plantago lanceolata*, *Trifolium*, *Rumex*. LOI is highest in this zone and averages 62.7%	European era not recorded in profile

[1]LOI = Loss on ignition

community, of which little remains in Taranaki. The canopy was dominated by tall *Metrosideros*. *Metrosideros* pollen is well known to be dispersed in substantial amounts, but only short distances (a few metres) from the parent plant (McGlone and Moar, 1997). Thus, such high levels (60–80%) of this pollen type indicate local dominance. The abundant wood in the Mimi and Waitoetoe peats indicates that trees were also growing in, or at least overhanging, the poorly drained soils. The *Metrosideros* pollen type contained variable grains and probably represents several species, including lianes. The majority are likely to be derived from tall forest trees of *Metrosideros robusta* rather than lianes because of the abundance of the pollen grains. However, as the present southern distributional limit of *M. excelsa* lies only about 10 km north of the Mimi River near Pukearuhe (Clarkson and Boase, 1982) it is conceivable that the *Metrosideros* pollen type could also include *M. excelsa. Metrosideros* pollen was also abundant in pollen cores from southern coastal Taranaki at Waverley Beach and Waiau Swamp (Bussell, 1988). However, at these sites, this pollen type clearly represents *M. robusta* as the sites are well beyond the southern distributional limit of *M. excelsa*.

Many other tall trees and shrubs were present in this forest community including *Prumnopitys ferruginea, P. taxifolia, Elaeocarpus dentatus, E. hookerianus* and *Vitex lucens* which were all present locally, as their pollen and seeds were found in the peat. *Laurelia novae-zelandiae*, *Alectryon excelsus, Knightia excelsa* leaves were found in the Mimi peat, and *Dysoxlyum spectabile*, *Dodonaea viscosa*, *Nestegis* spp., *Aristotelia serrata*, *Ascarina lucida*, *Griselinia lucida*, *Macropiper excelsum,* Urticaceae and others, were all recorded in the pollen at low levels. In addition, there would have been numerous other important species in coastal communities that are missing from the pollen record because they are either severely under-represented [e.g. *Beilshmiedia tawa* (rarely found in fossil records; Macphail and McQueen, 1983), *Geniostoma rupestre, Melicytus ramiflorus, Melicope ternata*] or included in a poorly differentiated taxonomic group of pollen (e.g. *Brachyglottis repanda*).

The pre-deforestation forest composition documented at these northern Taranaki coastal sites differs to that recorded from southern Taranaki coastal sites (Bussell, 1988) and northern coastal Waikato (Lees *et al*., 1998) where podocarp pollen, notably *Dacrydium cupressinum,* dominates the pollen profile. The pollen representation of *D. cupressinum* never exceeds 5% of the pollen sum in the profiles of this study, apart from the basal sample of the Mimi core, which may be as old as *c.* 3700 yr B.P. (as the three different AMS determinations from the basal sandy layer at the Mimi wetland is of mixed age: 754 ± 65 yr B.P., 1026 ± 63 yr B.P. and 3711 ± 60 yr B.P.; see Table 1). The *Metrosideros*-dominated forest community inferred from the pollen records remained relatively unchanged for at least 2500 years before clearance. Where *Metrosideros* forest was once locally common along the coastal fringes of northern Taranaki, it has since been almost totally destroyed by human activities.

Early Maori forest disturbance

Deforestation in northern coastal Taranaki appears to have occurred in two-stages: early and late. The Mimi pollen profile (Fig. 2) clearly records both stages of deforestation by fire; the Waitoetoe-A profile (Fig. 3) only records the period after deforestation; and the beginning of clearance is only just captured in the top 10 cm of the Waitoete-B profile (Fig. 4). The onset of initial Maori settlement impacts on the forest, marked by the first major increases in bracken and charcoal and the decline of the dominant canopy tree *Metrosideros*, was dated in the Mimi and Waitoetoe-B cores to 218 ± 57 yr B.P. and 222 ± 48 yr B.P. respectively (Table 1). *Potomogeton pectinatus* and Cyperaceae seeds from 80 cm in the Waitoetoe-A core returned a date of 342 ± 51 yr B.P.; although the pollen record clearly shows the whole profile is post-deforestation in age. Seeds from wetland plants often float and may be re-deposited out of context, long after initial deposition, and this may explain the age difference. Using the OxCal v3.6 combined probabilities method (Bronk Ramsey, 2001) the Waitoetoe-A determination is in poor agreement with those from Waitoetoe-B and Mimi [A = 27.7% (<A'c = 60.0%)]. However, the overall agreement index for all three determinations is acceptable at A = 57.4% (An = 40.8%). This gives a combined calibrated age range of AD 1640–1675 (40%), 1750–1770 (11.6%) and 1780–1800 (16.4%) at one standard deviation for early forest clearance at these sites.

The early deforestation event, seen most clearly in the Mimi core, differs from most other pollen diagrams in New Zealand in several respects: 1) it occurs several centuries later, i.e., the mid-17th century rather than AD 1200–1400 (McGlone and Wilmshurst, 1999), and, 2) there is a smaller-scale fire disturbance that precedes major clearance (shown by an increase of *Aristotelia serrata, Schefflera digitata, Pteridium esculentum* but at relatively low levels) with little change in the dominant *Metrosideros* cover. Major components of the sub-canopy in the Mimi pollen diagram (particularly *Cyathea* spp. tree ferns and *Ascarina lucida)* decline rapidly in the early phase of burning, and suggest small patchy clearances in the forest. This small-scale clearance strategy contrasts with the more commonly recorded rapid and widespread deforestation in the drier parts of New Zealand. The high rainfall of coastal Taranaki may have meant that extensive burning of the forest was not so easily achieved.

The clearings were probably used for gardens, housing areas and for planting karaka (*Corynocarpus laevigatus*). Dieffenbach (1843) describes Maori tending small gardens in forest clearings in Taranaki in the 1840s, where potato, taro, onion, watermelon and pumpkin crops were being grown. It is likely that similar forest plots were also used for kumara and gourds in coastal Taranaki in the past.

Karaka are still present in small groves in the Mimi and Waitoetoe catchments today, and found at many pa sites in Taranaki (Stowe, 2003). The tree was grown by Maori for its abundant supply of large edible fruits and seeds (Best, 1942), and was moved around New Zealand and planted in groves (Molloy, 1990).

Many karaka trees at Taranaki pa sites are large-fruited compared with natural stands in Auckland, suggesting selection by Maori for superior fruit size (Platt, 2003). Karaka pollen is severely under-represented and rarely found in New Zealand fossil pollen records (Macphail and McQueen, 1983; McGlone, 1988), and its presence in both Waitoetoe cores in the early deforestation phase, and not before, suggests this tree was planted in this area by Maori in newly created forest clearings. A similar occurrence of karaka pollen was found in a peat core from the Kauaeranga Valley, Coromandel (Byrami *et al*., 2002), at the same time as the earliest indication of forest disturbance (increase of bracken spores and charcoal).

Pollen records from upland bogs on Mt Taranaki show that, at altitudes where bracken could not thrive, there was a marked and sustained increase in long-distance-dispersed bracken spores beginning after the Newall eruption (450 ± 30 yr B.P. or *c.* AD 1400) (McGlone *et al*., 1988). Before this time, bracken spores were uncommon and recorded only at trace levels. McGlone *et al*. (1988) attributed this increase of wind-blown bracken spores to deforestation by fire on the coastal strip of Taranaki. Although this is approximately in agreement with the poorly constrained dating of deforestation on the southern coast of Taranaki (610 ± 80 yr B.P.) by Bussell (1988) (calibrated ages statistically overlap at 95% confidence interval), it is about 200 years earlier than the age of deforestation in the Mimi and Waitoetoe sites in this study. The Mimi and Waitoetoe-B pollen records show that bracken spores and charcoal fragments are not recorded before deforestation began in the late AD 1600s. This suggests that the earlier forest clearances recorded by McGlone *et al.* (1988) and Bussell (1988) are not showing up as long-distance elements in the pollen profiles from the northern coastal sites in this study. This absence of a regional pollen signal is indicative of the dominance of local pollen at the study sites; the sites strongly reflect the immediate vegetation cover. The difference in timing of early forest clearance in different parts of Taranaki highlights the patchy nature of fire disturbance in a high-rainfall landscape that was difficult to burn. Evidence of this patchiness persisted into the 1840s; Dieffenbach (1843) described the vegetation of coastal Taranaki as having numerous groves of forest remaining amongst the fern-shrubland. Relatively late deforestation is also recorded in other regions of New Zealand with similar annual rainfall (2000 mm or more), for example *c.* AD 1500–1600 at Lake Waikaremoana (Newnham, 1998). In drier areas that were easier to burn, fires would have resulted in rapid, widespread deforestation, and this is likely to explain the general agreement in dates for earliest forest clearance in widely separated sites (McGlone and Wilmshurst, 1999).

Late Maori forest clearance

The early phase of clearance was followed by a later, more widespread clearance, indicated by a steady and sustained decline of *Metrosideros*, *Schefflera digitata, Aristotelia serrata, Ascarina lucida,* and of several tall forest taxa previously recorded in low levels, including *Elaeocarpus* sp. and *Laurelia novae-zelandiae.* At the same time, there is a marked increase of ground fern spores including *Pteridium esculentum* and *Blechnum procerum*, and of charcoal fragments. Other changes include an increase of *Typha orientalis*, Cyperaceae, and seral scrub, including *Leptospermum* sp. and *Coriaria* sp. Hornwort spores also increase, responding favourably to exposed disturbed soils [as found in other pollen profiles after forest clearance, e.g. Wilmshurst *et al.* (1999)]. The pollen diagrams show the arrival of introduced European taxa after widespread deforestation, indicating that, although late, forest clearance had begun well before European farming activities began in the 1870s (Lambert and Henry, 2000). Attempts to date the beginning of this later phase of clearance using radiocarbon dating failed; AMS determinations were modern (Table 1), presumably the samples were contaminated with younger material (most likely rootlets). However, an estimate of late Maori forest clearance can be calculated from rates of peat accumulation in the Mimi core (the most complete profile). A cubic spline interpolation between two established ages (AD 1870 at 18 cm where exotic taxa occur, and AD 1640 at 95 cm, which is the earliest possible age for the combined calibrated age for initial forest clearance) gives an approximate age of AD 1720 for the onset of widespread clearance (recorded at 70 cm). This age estimate is consistent with the presence of 83 fortified pa around the study area. Fortified pa sites are associated with cleared areas where crops were harvested, and the storage pits found on pa sites support this view. After the 1820s, this form of pa was modified to accommodate the changed conditions of warfare associated with muskets, and musket pa are relatively rare in the study area. Traditional and historical evidence suggests intensive occupation until the 1820s at which time Ngati Mutunga's settlements were disturbed by wars with raiding northern tribes Nga Puhi, Ngati Toa and Waikato (Wakefield, 1908; Keenan, 2002).

Macrofossil evidence of early kiore presence

Many well-preserved woody seed cases were recovered from the basal sandy layer in the Mimi site, and throughout the Waitoetoe-B profile, including *Prumnopitys ferruginea, P. taxifolia, Elaeocarpus* sp. and *Vitex lucens* indicating the local occurrence of these trees. All of these species occurred at low percentages in the pollen profiles and may be under-represented. The presence of these seeds highlights the usefulness of macrofossils in expanding the local vegetation history of a site where many species are likely to be under-represented or poorly represented in the pollen record.

The seed cases also reveal additional information about the local environment. In the basal sandy layer at Mimi, many seed cases, including *Prumnopitys ferruginea, P. taxifolia*, and *Elaeocarpus* sp.l, had small neat holes cut through their woody cases; microscopic examination revealed distinctive incisor marks. Two such gnawed *Prumnopitys ferruginea* seed cases collected from the basal sandy layer in the Mimi peat deposits were dated by AMS, and they returned ages of 780 ± 70 yr B.P. and 754 ± 65 yr B.P. (Table 1). We attribute these gnawed holes to predation by kiore (*Rattus exulans* or Pacific rat). The gnawed seed cases provide unequivocal evidence of kiore presence in the area because: 1) no native animal is capable of leaving such marks on seeds; 2) no other rats or mice were present in New Zealand until after European contact in the 1800s; and 3) the incisor marks are identical to those of modern kiore-gnawed woody seed cases (J. Wilmshurst, *unpubl. data*). The AMS determinations of these gnawed seed cases indicate that kiore were present at the Mimi site at least 200–400 years before the first signs of local Maori settlement impacts show up in the pollen diagram from the same peat profile.

The earliest archaeological evidence for human presence in Taranaki comes from moa hunting sites along the southern Taranaki coast; and kiore bones were associated with these cultural deposits (Anderson, 1989). However, Anderson (1989) suggests these moa butchery sites were relatively short-lived, and no large-scale or permanent human settlements were associated with them. Population modelling of moa also suggests these birds went extinct very quickly (perhaps <100 years) as a result of human predation (Holdaway and Jacomb, 2000). Moa do not seem to have been common in closed forest habitats and there was little penetration of dense forest by early Maori in the North Island (Anderson, 1989). Therefore, although Maori were using the coastal area for hunting and gathering, permanent settlement of northern coastal Taranaki may not have occurred until several hundred years later. The difference between the dates for gnawed seeds and deforestation at the same sites implies that kiore spread rapidly and independently across the landscape after their initial introduction to New Zealand by Maori, and did not rely on landscape modification, or people, to assist their dispersal.

Seed predation by kiore has adversely affected the regeneration of several species of plants on offshore islands in New Zealand (Campbell, 1978; Campbell and Atkinson, 2002), and on other Pacific islands (Mosby and Wodzicki, 1973; McConkey *et al*., 2003). Seed predation by kiore has also been implicated, from the pollen record, as a cause of compositional change in Hawaiian forests just before Polynesian settlement (Athens *et al*., 2002). However, the pollen records in this study show no change in composition over the approximately 200–400 years that kiore were present in the forests before Maori deforestation. Although kiore were eating seeds of forest trees, including *Prumnopitys taxifolia*, *P. ferruginea*, and *Elaeocarpus* sp. which are all represented in the pollen record, their pollen curves show no change until Maori deforestation by fire. Potential rat predation effects on the recruitment of these taxa would be difficult to detect in the pollen records as the trees are long-lived. Also, before kiore arrival, predation levels by native birds may have been similar. Although undetected in this study, there may be more chance of identifying short-lived species responses to kiore seed-predation, but separating these in the pollen record from other environmental variables that can also influence regeneration patterns would be a major challenge.

Wetland changes

After deforestation the sediment deposits became more organic towards the surface as the local vegetation changed from forest to herbaceous wetland. The peat deposits at Waitoetoe-A were shallower and situated further upstream than the Waitoetoe-B site. The peat deposits at Waitoetoe-B are relatively deep (>3 m) and older, suggesting peat was accumulating for some time before human presence at this site. However, the Waitoetoe-A profile shows that peat began forming directly upon basal papa sediments some time after forest clearance had begun at this site, during the early Maori period, zone 2 of the pollen diagram (Fig. 3). The post-deforestation increase of *T. orientalis* and Cyperaceae (indicative of higher water tables) in the late Maori period (zone 3) in the Waitoetoe-A (and Mimi) core, suggests that forest clearance caused local hydrological changes to valley bottoms of both Mimi and Waitoetoe. However, there is no evidence for post-deforestation erosion. Rather, forest clearance and decreased evapotranspiration caused increased runoff and poor drainage, encouraging the spread of wetland taxa (including *T. orientalis*, *Myriophyllum* sp. and Cyperaceae) and increasing the rates of peat accumulation. The spread of *T. orientalis* may have been encouraged by Maori, as various parts of this plant were used for numerous domestic purposes. It was probably peat under this type of wetland vegetation into which Maori placed treasured and domestic wooden items for preservation.

European clearance

Both the Mimi and Waitoetoe-A pollen profiles clearly show the influence of European settlement by the appearance of many exotic pollen taxa associated with farming activities (e.g. *Rumex*, *Taraxacum*, Pinaceae, *Salix*, Cupressaceae), with an increase of grass pollen and a decline in *Pteridium esculentum*. *Sphagnum* moss spores are recorded in the surface layers of the Mimi profile, suggesting a short-term favourable response to drainage. Attempts were made to drain the Mimi swamp in 1953, and to remove *Salix* sp. and *T. orientalis*, but the farm was sold soon after this date, and the wetland reverted back to a shrubby swamp with *Leptospermum*, small-leaved *Coprosma* spp., *Sphagnum* and *Phormium tenax* (Jim Phillips, *pers. comm.*). The surface pollen record from the Mimi core agrees with the current farmer's recollection of changes in the wetland since the 1950s, with the exception of *Phormium,* which is not represented in the pollen record. However, bird-pollinated *Phormium* is commonly under-represented in the New Zealand pollen records (Macphail and McQueen, 1983). The European zone is missing from the Waitoetoe-B record, because the surface peat has been destroyed by recent drainage.

Conclusions

The record of relatively late human settlement and impact on the environment of northern coastal Taranaki reveals significant differences compared with South Taranaki and the rest of New Zealand in general. Although kiore were present in the study region at the same time as the permanent human settlement of New Zealand (from *c.* AD 1200), permanent settlement and initial human disturbance of the vegetation began much later in the study area, in the mid-17th century, and brought about small shifts in vegetation composition. These intitial changes indicate patches were cleared in the forest, most likely for swidden horticulture. Initial human impacts in this region began about 200 years after similar changes are recorded in pollen records from wetlands on Mount Taranaki and in South Taranaki (*c.* AD 1500), and *c.* 450 years later than the major forest clearances of the drier regions (mostly eastern) of New Zealand (McGlone and Wilmshurst, 1999). These results suggest a mosaic pattern of human colonisation and settlement in northern coastal Taranaki and a relatively late expansion of Maori settlement into difficult terrain. Settlement of previously avoided, wet coastal environments may have been related to population pressure and conflict.

The data presented here collectively reveal that numerous indicators of human presence (archaeological sites, extinctions, kiore presence and fire disturbance) are required for a comprehensive picture of settlement. It may be difficult to use vegetation change alone to identify initial human settlement in wet, densely forested, hard-to-burn areas of New Zealand. The radiocarbon determinations and pollen data also emphasise the need for both regional and local pollen records, for a deeper understanding of deforestation processes in the varied terrain of New Zealand.

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