Establishing an accurate date for earliest Polynesian settlement in New Zealand is essential for understanding patterns of settlement and associated environmental impacts, and the processes and rates of cultural change in Eastern Polynesia. Tephra deposits from five volcanic centres, together with exotic sea-rafted pumice, provide isochronous constraints on the timing of earliest settlement and human impacts in northern New Zealand. A local basaltic tephra from Rangitoto Island (Auckland) and locally distributed andesitic tephras from Egmont volcano directly date human occupation to c. AD 1400–1450. Distal andesitic tephras (Tufa Trig Formation) from Mt Ruapehu, Tongariro volcanic centre, help constrain the timing of earliest anthropogenic deforestation signals in Hawke’s Bay. Sea-rafted Loisels Pumice(s), although of uncertain stratigraphic reliability in places, overlies cultural remains that can be no younger than c. AD 1350 along the east coast, North Island. The regionally extensive rhyolitic Kaharoa Tephra, which erupted from Okataina volcano between c. AD 1300–1390, is the critical “settlement layer” datum for dating prehistory in the North Island: no human artefacts are recorded beneath it and the earliest inferred environmental impacts by humans are dated to c. AD 1280, just prior to its deposition. This maximum date matches the earliest radiocarbon dates derived for both settlement and human impacts from archaeological and natural sites (c. AD 1250), and implies that the onset of deforestation was essentially contemporaneous with initial settlement.

The widespread rhyolitic Taupo Tephra, which erupted from Taupo volcano c. AD 200, provides an isochronous benchmark well before earliest settlement. The tephra may coincide approximately with a putative earlier transient contact in New Zealand based on Pacific rat-bone (Rattus exulans) dates. More precise calendrical dates on the tephras—via dendrochronology or ice-core records or other dating methods—would help refine assessment of the timing of earliest settlement, while extending the distributional range of critical tephra layers, through application of crypto-tephra analysis, could lead to a greater understanding of settlement patterns.
questioned over the past decade, and two contrasting alternative models have emerged favouring either “early” or “late” settlement (Table 1).

New settlement models and the importance of resolution

Sutton (1987) argued for early settlement (i.e. a “long” prehistory) following Kirch’s (1986) reanalysis of the earliest settlement in Eastern Polynesia, and suggested that evidence of vegetation and landscape disturbance at natural sites including lakes and swamps was indicative of early human disturbance c. AD 0–500. This view was supported by Kirch & Ellison (1994), Sutton (1994b), and Elliot et al. (1995). Recent accelerator-based radiocarbon dates on bone gelatin of the Pacific rat *Rattus exulans*, a probable human commensal (Roberts, 1991; Matisoo-Smith, 1994; Allen et al., 1996), from predator-prey sites in New Zealand are up to 2000 ^14C^ BP (Holdaway, 1996, 1999), thus apparently supporting early human contact. The reliability of the dates has been discussed (Anderson, 1996a, 1998; Ladefoged et al., 1997; see also Holdaway & Anderson, 1998; Petchey & Higham, 2000), and the dating procedures investigated (Sparks et al., 1997; Beavan & Sparks, 1998; Sparks, 1998; Holdaway & Beavan, 1999). For some reason, rat-bone dates from two well-dated archaeological sites at Shag River Mouth and Pleasant River Mouth do not agree with dates on other materials at these sites (Anderson, 1996b; Smith & Anderson, 1998; Petchey, 1999; Petchey & Higham, 2000). Rat-bone dates, all <500 ^14C^ BP, from a third well-dated archaeological site at Pauatahanui are consistent with dates on marine shells from identical contexts (Beavan Athfield et al., 1999).

Although it is likely that the rats were initially transported to New Zealand by early Polynesian seafarers, either deliberately as a food source or unwittingly as stowaways, alternative explanations for their arrival have been suggested (Langdon, 1995; Anderson, 1996b; Spennemann & Ambrose, 1997). Analyses of mitochondrial DNA from the rats have shown New Zealand *R. exulans* populations to be highly divergent and, regardless of the timing of their introduction, derived from multiple sources including possibly the western Pacific as well as Eastern Polynesia (Matisoo-Smith et al., 1998).

Arguments for the late settlement model (i.e. a “short” prehistory) are based on a comprehensive analysis of the earliest radiocarbon dates associated with undoubted human occupation or cultural sites in New Zealand (Anderson, 1991, 1994, 1995). The analysis, using strict criteria of acceptability (Spriggs, 1989), indicated that earliest settlement was not before c. AD 1150–1300. Similar conclusions were reached by McFadgen et al. (1994), Higham & Hogg (1997), and Higham et al. (1999). Interpretations of natural sites, mainly from palynological studies, further support the late settlement model (McFadgen, 1994a; Wilmshurst, 1997; Wilmshurst et al., 1997; Higham & Lowe, 1998; Horrocks & Ogden, 1998; Newnham et al., 1998a, 1998b; Ogden et al., 1998; McGlone & Wilmshurst, 1999; Horrocks et al., 2000a).

Thus, although up to c. 1300 years separate the “early” and “late” models for earliest settlement, New Zealand’s prehistory is exceptionally brief no matter which model applies (the period of pre-European contact is only c. 500 years long at most according to the late settlement model). Such a short prehistory limits the effectiveness of radiocarbon dating for defining the order of archaeological events (McFadgen, 1982; McFadgen et al., 1994). Accurately fixing the dates of first contact and first settlement is important for distinguishing between the natural and cultural processes that have shaped the New Zealand environment. During this short interval, humans have dramatically transformed the landscape and environment at rates that may be without parallel, and hence knowledge of direct and indirect anthropogenic change is essential for understanding changes in New Zealand’s biodiversity and how a tropical culture was adapted to a temperate environment (McGlone, 1989; McGlone et al., 1994; Challis, 1996; Taylor et al., 1997; McGlone & Wilmshurst, 1999; Newnham et al., 1999). The manner of New Zealand’s initial colonisation is another important archaeological problem (Caughley, 1988; Anderson & McGovern-Wilson, 1990; Anderson, 1991; Law, 1994; Davidson et al., 1996).

Resolving the uncertainty in timing of earliest settlement is therefore a major challenge for dating techniques, and underpins further progress in determining settlement patterns, their processes and associated environmental impacts in both Eastern Polynesia and New Zealand, and in understanding processes and rates of cultural change. Such an understanding is also relevant to parallel studies of environmental and cultural change and the so-called *landnám* or phase following peripheral colonisation between c. AD 850 and AD 1000 in parts of the North Atlantic region (Faroe, Iceland, Greenland, Newfoundland) (e.g. Dugmore & Buckland, 1991; Butlin & Roberts, 1995;
In this paper we review the role of tephrochronology—the use of tephra layers as chronological marker beds to establish numerical or relative ages—in dating New Zealand prehistory, especially the question of timing of earliest settlement. This method potentially provides a means of circumventing the interpretative difficulties associated with radiocarbon dating at both archaeological and natural sites. This is because tephra layers, the unconsolidated primary pyroclastic products of volcanic eruptions (Hunt & Lowe, in press), provide virtually instantaneous time-equivalent (isochronous) marker horizons that can be correlated between sites independently of radiometric (or biostratigraphic) dating (Lowe et al., 1998; Newnham et al., 1998b; Newnham & Lowe, 1999). That tephra deposits are found in a variety of depositional environments means they have the capacity, once fingerprinted by lithological, mineralogical or geochemical methods, for linking associated archaeological or environmental signals in an unambiguous manner that no other dating or correlative technique can yet provide (Hunt, 1999; Shane, 2000).

**Tephras Relevant to New Zealand Archaeology**

Tephra deposits from five volcanic centres (Egmont, Auckland, Tongariro, Okataina, and Taupo) in the volcanically-active North Island assume importance in dating New Zealand’s prehistory (Figure 1). The eruptions from the Egmont and Auckland centres have relatively localised distributions, those from the Tongariro centre are more distal, and the Okataina- and Taupo-derived tephras (Kaharoa and Taupo, respectively) are very widely dispersed. In addition to the tephras from these five centres, foreign sea-rafted tephra deposits known as “Loisels Pumice” are also relevant at some coastal sites along eastern North Island (Figure 1). These tephra deposits, characterised, mapped and dated in previous studies, are each discussed below with regard to their role in dating earliest settlement or impact. Their stratigraphic and age relationships are summarised in Figure 2.

**Egmont-derived tephras**

The andesitic Egmont volcanic centre, dominated by the stratovolcano of Mt Taranaki, has erupted three major tephra formations (Tahurangi, Burrell, and Newall) in the past 500 years, each formation comprising one of four named members (Druce, 1966; Topping, 1972; Neall, 1972, 1979; Neall & Alloway, 1986; Neall et al., 1986; Lees & Neall, 1993). Some of the tephra layers are interbedded with cultural remains in the form of in situ rounded cooking stones (cobbles) in Maori earth ovens (umu) (Figure 2). These were first recognised on Mt Taranaki by Oliver (1931). Other sites have been subsequently investigated by Topping (1974) and Alloway et al. (1990). The umu have been dated using the constraining tephra layers and by radiocarbon assays on associated charcoal, as described below.

The latest definitive eruptive event at the Egmont centre, Tahurangi Ash, occurred possibly in c. AD 1755 on the basis of tree-ring analysis (Druce, 1966) but may have been later, near c. AD 1860, from palynological analysis and peat accumulation rates (Lees & Neall, 1993). Another small pyroclastic eruption involving emplacement of Unit 1A of the Maero Debris Flows may have occurred only c. 100 years ago (Neall & Alloway, 1986, 1991).

The Burrell event includes two Puniho and two Burrell members. The latter were erupted in c. AD 1655 (Burrell Lapilli), based on tree-ring studies (Druce, 1966), and in c. AD 1585 or earlier (Burrell Ash) on the basis of peat accumulation rates (Lees & Neall, 1993).

The Newall event, comprising two Waiweranui and two Newall members, was estimated to have occurred in c. AD 1604 from tree-ring analysis (Druce, 1966). However, three radiocarbon dates on material associated with the Newall eruptives (Neall, 1972), calibrated using Stuiver & Reimer (1993) and Stuiver & Pearson (1993) and the intercepts method, and corrected for the minus-27 years Southern Hemisphere offset determined by McCormac et al. (1998a, 1998b), range (at 1-sigma levels) from AD 1438 to 1615 (mid-point AD 1546) (NZ-720) (numbers prefixed “NZ” refer to the New Zealand now Rafter Radiocarbon Dating Laboratory number), from AD 1452 to 1630 (mid-point AD 1484) (NZ-941), and from AD 1440 to 1483 (mid-point AD 1454) (NZ-1141). Thus the Waiweranui/Newall tephras were erupted probably around AD 1500 (McGlone et al., 1988; Lees & Neall, 1993) with a maximum age a few decades earlier, possibly around c. AD 1450 to 1480 based on intercept mid-points of the age ranges.

At one site on Mt Taranaki, the Maori cooking stones are overlain by Burrell Ash and underlain by Waiweranui Lapilli (Alloway et al., 1990), and so on the basis of tephrochronology the site was occupied, at the earliest, in c. AD 1500 or a little before (Figure 2). Charcoal from within the umu ranges in age, using the calibration procedure described above, from AD 1480 to 1653 (multiple mid-points AD 1528, 1551, 1634) (NZ-64), consistent with this finding. A second site is slightly older, the cooking stones being overlain by a local “unnamed” tephra that underlies Newall Ash (Topping, 1974). A weak palaeosol is associated with the “unnamed” tephra, indicating that some time elapsed before it was buried by the Newall Ash. The tephrochronology and stratigraphy therefore indicate that the umu at this site very likely pre-dates c. AD 1500. This conclusion is supported by a date on charcoal (derived from short-lived subalpine scrub) from the oven (Topping, 1974) that has a calibrated age range of AD 1434–1486 (mid-point AD 1449) (NZ-1516), i.e. the site was occupied as early as c. AD 1450 (Figure 2).
In summary, the earliest-known cultural remains associated with the Egmont-derived tephras are dated to c. AD 1450. The earliest human impacts (deforestation) in the Egmont area, based on palynological evidence for the initiation of a distinct and rapid increase in *Pteridium* (bracken) spores, occurred just before deposition of the Newall Ash (McGlone et al., 1988) (i.e. at about the same time).

**Auckland-derived Rangitoto Tephra**

The latest eruption in the basaltic Auckland volcanic field formed Rangitoto Island and the locally-distributed Rangitoto Tephra (Figure 1; Brothers & Golson, 1959; Froggatt & Lowe, 1990; Kermode, 1992; Allen & Smith, 1994). Dates on the eruption, previously ambiguous, have been reviewed by Nichol...
(1992) who concluded that the eruption occurred probably in c. AD 1400, at the earliest, from assessment of multiple dates based on radiocarbon (c. AD 1400–1500), palaeomagnetic (c. AD 1420; Robertson, 1986), and thermoluminescence (c. AD 1400–1420; Adams, 1986; Wood, 1991) methods. This assessment was supported by McFadgen (1996). The youngest radiocarbon sample (NZ-1167) on twigs is probably closest to providing the “correct” date; calibrated as above, it ranges from AD 1442 to 1638 with an intercept mid-point at AD 1481.

Cultural remains underlie the Rangitoto Tephra where it was deposited on the adjacent Motutapu Island (Davidson, 1978), and human and dog footprints, together with evidence for gardening activities, are preserved within the tephra deposits at the Sunde site at West Point, Motutapu Island (Nichol, 1981, 1982, 1988; Figure 1). Thus, tephrochronology indicates that the earliest Maori inhabitants on Motutapu were there before c. AD 1400, in good agreement with six hydration dates, ranging from c. AD 1322 to 1508, obtained recently from obsidian artefacts associated with Rangitoto Tephra at the Sunde site (Stevenson et al., 1996) (the error-weighted mean age for the obsidian hydration dates is AD 1385 ± 35). This conclusion is consistent with archaeometric evidence from elsewhere in the Auckland volcanic field, which demonstrates that human occupation occurred before c. AD 1500 (e.g. Davidson, 1993; Higham & Hogg, 1997).

**Tongariro-derived Tufa Trig tephras**

The latest sustained eruptions of the Tongariro volcanic centre occurred at Mt Ruapehu in AD 1995 and 1996 (Figure 1; Houghton et al., 1996). The tephras produced during these eruptions have been included in the Tufa Trig Formation, which comprises 19 named members erupted from Mt Ruapehu volcano since c. 1850 14C BP (Donoghue et al., 1995, 1997). Two of the most widespread members of this formation, Tufa Trig members T7 and T8, have been identified in sediments in lakes Tutira and Rotonuiaha in Hawke’s Bay, eastern North Island (Figure 1; Eden & Froggatt, 1996; Page & Trustrum, 1997; Wilmshurst, 1997).
Member Tf5 is imprecisely dated between c. AD 1050 and 1400, based on the 2-sigma ranges of two radiocarbon ages on peat, one above the tephra (650 ± 50 $^{14}$C BP, Wk-1488) (numbers prefixed “Wk” refer to the Waikato Radiocarbon Dating Laboratory number) and one below it (830 ± 60 $^{14}$C BP, Wk-1489) at Ngamatae swamp near Waiouru (Donohgue et al., 1995). In Lake Rotonuiaha, Tf5 is overlain by Kaharoa Tephra, which has an age of 665 ± 15 $^{14}$C BP (Lowe et al., 1998; see below), consistent with Wk-1488. Member Tf8, although not dated directly, stratigraphically overlies both Kaharoa Tephra ( provisionally correlated to a thin palaeosol layer between members Tf7 and Tf8 near Mt Ruapehu: Donohgue et al., 1997) and member Tf5, and thus is younger than Kaharoa Tephra and Wk-1488. Exactly how much younger is currently unknown.

The earliest anthropogenetic deforestation signals in Hawke’s Bay, determined using palynological and multivariate analyses (Wilmshurst et al., 1997), occur a little above Tf8 in Lake Tutira (Tf5 lies well below the impact signal), and just above Kaharoa Tephra and Tf5 in Lake Rotonuiaha (Wilmshurst, 1997). More accurate dating of tephras Tf5 and Tf8 would help constrain the timing of initial deforestation in Hawke’s Bay, which is currently estimated at approximately c. AD 1450 (Page & Trustrum, 1997; Wilmshurst, 1997).

We are not aware of any archaeological sites or prehistoric cultural remains buried by Tufa Trig members Tf5–Tf8.

**Sea-rafted Loisels Pumice**

Exotic sea-rafted Loisels Pumice, dacitic to rhyolitic in composition, occurs along eastern North Island (Figure 1) and Chatham Island coastlines where it has been used as a stratigraphic marker (McFadgen, 1985, 1994a; Brook & Goulstone, 1999). It may also occur on the Queensland coast, Australia (Ward et al., 1999; Ward & Little, 2000). Because it is prone to shoreline reworking, and because error-weighted mean ages associated with it fall into two clusters (610 ± 20 and 1250 ± 40 $^{14}$C BP), its value as a “universal” marker horizon has been questioned (Pullar et al., 1977; Froggatt & Lowe, 1990; Osborne et al., 1991; Brook, 1999). Furthermore, Shane et al. (1998) showed it to be the product of several eruptive events from different volcanoes, and suggested therefore that the divergence in radiocarbon dates may reflect two or more drift events (assuming minimal local reworking) (see also Shane & Gregory, 1999; Ward, 2000). Alternatively, the older dates, all on shell material, may represent recycled material that reflects a large (unknown) in-built age (McFadgen, 1994b) and therefore these “older” deposits may have no chronostratigraphic significance. Brook (1999) showed this to be the case from primary Loisels Pumice at Tokerau Beach in northern New Zealand.

Despite its multisource origin and the uncertainty regarding the stratigraphic relevance of the older group of pumices, Loisels Pumice nevertheless is potentially useful in constraining the timing of early settlement at some sites. Stratigraphically it directly underlies Rangitoto Tephra at several locations on Motutapu Island in the form of lumps of pumice embedded in the underside of the Rangitoto ash deposits (Law, 1975; McFadgen, 1981, 1996), suggesting that it was washed up on the shoreline and then buried very soon after. At these sites Loisels Pumice therefore immediately pre-dates c. AD 1400. This date is consistent with the “younger” age estimate for Loisels Pumice of between c. AD 1290 and 1440 ( approximate mid-range age c. AD 1350) (McFadgen, 1994b, 1996; Brook, 1999; Ward et al., 1999). Optical dating (e.g. see Aitken, 1992; Stokes, 1999) may help to determine if clasts of Loisels Pumice from the different sources have significantly different ages.

The stratigraphic relationship of Loisels Pumice and Kaharoa Tephra is equivocal (Pullar et al., 1977; Shepherd et al., 1997). Pullar et al. (1977) considered, on balance, the first stranding of (younger) Loisels Pumice to post-date Kaharoa Tephra but this has yet to be confirmed or otherwise stratigraphically.

Cultural remains underlying Loisels Pumice occur commonly along the east coast of the North Island (Figure 1; Anderson, 1991; McFadgen, 1994a). Consequently, the timing of settlement associated with these remains is earlier than c. AD 1350 using the above “mid-range” date and assuming that the Loisels Pumice has not been reworked since its initial stranding.

**Okataina-derived Kaharoa Tephra**

The rhyolitic Kaharoa Tephra, erupted from Mt Tarawera in the Okataina volcanic centre, was deposited over at least one quarter of North Island and offshore Bay of Plenty (Figure 1; Kohn & Glasby, 1978; Lowe et al., 1998). The age of the eruption has been defined at 665 ± 15 $^{14}$C BP based on cluster analysis both of 22 unscreened radiocarbon ages and on three sets of screened ages selected to minimise the effects of inbuilt age or contamination (Lowe et al., 1998). This age is equivalent to calibrated dates ranging from c. AD 1300–1390 at the 1-sigma level (the range at the 2-sigma level is c. AD 1290–1400) (Lowe et al., 1998).

For two reasons, the Kaharoa Tephra is a critical tephra marker bed for dating New Zealand’s prehistory. Firstly, no cultural remains are known to occur beneath it and so it provides a maximum age for settlement in eastern North Island of c. AD 1300 (Figure 2; McFadgen, 1981; Anderson, 1991; Shepherd et al., 1997). Secondly, palynological analyses of around a dozen pollen sites in this region, all containing the Kaharoa Tephra datum, indicate sustained deforestation very close to the time of its deposition.
(Wilmshurst, 1997; Newnham et al., 1998b; Horrocks et al., 1999, 2000a, 2000b; Wilmshurst et al., 1999). At five pollen sites the evidence for such deforestation (e.g. sustained rise in bracken, charcoal) occurs stratigraphically just below the Kaharoa Tephra layer. (A similar pattern is evident with independent opal phytolith data in tephras-containing sequences: Sase et al., 1988; Kondo et al., 1994; Sase & Hosono, 1996.) This initial deforestation signal occurs a few decades at the most before deposition of the Kaharoa Tephra, at around c. AD 1285 (Newnham et al., 1998b; Lowe et al., in press).

Thus, the earliest inferred human-induced environmental impacts in eastern North Island are estimated from the pollen records to have occurred no earlier than c. AD 1280. This conclusion implies that earliest Maori in New Zealand may have witnessed the Kaharoa eruption very soon after their arrival. Such speculation is supported by an oral legend of the Ngati Awa tribal group that refers to an ancient eruption of Mt Tarawera (i.e. a volcanic event preceding the historical 10 June, AD 1886 Tarawera eruption: Figure 2) (McCraw, 1993; see also Keam, 1988). We emphasise that this age estimate for the start of deforestation is constrained stratigraphically by the compositionally distinctive Kaharoa Tephra layer, thereby largely obviating the problems associated with interpreting radiocarbon dates from pollen records alone, which may carry a risk of contamination by inwashed carbon (Newnham et al., 1998b; McGlone & Wilmshurst, 1999; Wilmshurst et al., 1999; Lowe et al., in press). It is in close agreement (Figure 2) with dates of c. AD 1200–1400 derived for sustained deforestation at natural sites elsewhere in New Zealand (Anderson, 1991; Ogden et al., 1998; McGlone & Wilmshurst, 1999). Similarly, the date matches the maximum dates of c. AD 1250–1300 obtained by the Waikato Radiocarbon Dating Laboratory (Higham & Hogg, 1997) on multiple archaeological sites throughout New Zealand, including some containing the earliest known (archaic) artefacts (e.g. Wairau Bar, Figure 1: Higham et al., 1999). The Kaharoa Tephra may therefore be regarded as equivalent to ländhám or “settlement” tephra layers in Iceland (e.g. the Vatnáöldur “Settlement Layer”, Ländhámslag, dated AD mid-870s: Larsen, 1984; Buckland et al., 1995; Zielinski et al., 1997; Boygle, 1999) that coincide closely with anthropogenic impacts relating to permanent settlement (Larsen, 1984). That the maximum date for the onset of deforestation is similar to the earliest settlement date obtained from archaeological sites implies that the onset of deforestation through human activities was essentially contemporaneous with initial settlement (Lowe et al., in press).

**Taupo-derived Taupo Tephra**

The rhyolitic Taupo Tephra (known as Unit-Y by Wilson, 1993) was erupted in c. AD 200 from vents in the northern part of Lake Taupo within the Taupo volcanic centre during an exceptionally powerful and complex event (Walker, 1980; Wilson & Walker, 1985; Wilson, 1993; Smith & Houghton, 1995). The plinian (Subunit-Y5) and other fallout material provide an extensive marker bed deposit throughout North Island and beyond. Although botanical and dendrochronological data indicate that the eruption occurred during the (austral) late summer or early autumn (Clarkson et al., 1988; Palmer et al., 1988), the specific year of the eruption is debated (Lowe & de Lange, 2000): calibrated dates (1-sigma range) for multiple radiocarbon ages (1850 ± 10 14C BP, N=41; 1845 ± 19 14C BP, N=7) range from AD 130–240; ice-core data suggest AD 181 ± 2 (Zielinski et al., 1994); tree-ring data indicate AD 232 ± 15 (Sparks et al., 1995); and disputed interpretations of ancient historical records suggest c. AD 186 (Wilson et al., 1980; cf. Froggatt, 1981; Stothers & Rampino, 1983). Taupo Tephra is stratigraphically overlain by Kaharoa Tephra, and approximately 1100 calendar years separate them.

Because there are no known cultural deposits recorded prior to Kaharoa Tephra (Figure 2), and because disturbances in the pollen record in the same period, as indicated palynologically by increases in bracken and other seral taxa, are indistinguishable from natural background events (McGlone et al., 1994; Wilmshurst et al., 1997; Newnham et al., 1998b; Lowe et al., in press), the Taupo Tephra provides an isochronous benchmark for natural conditions well before (c. 1100 years) earliest human settlement. However, its deposition coincides approximately with the timing of the purported early transient contact by humans in New Zealand based on the early Pacific rat-bone dates as discussed previously (Figure 2; Holdaway, 1996, 1999). The tephra may therefore mark roughly the start of sustained impact on the natural biota by an introduced predator. Accordingly, a systematic search of selected parts of the Taupo-age shoreline, identifiable by fallout tephra and sea-rafted pumice along much of the New Zealand coast (McFadgen, 1985, 1994a), would be warranted to test for more definitive evidence of early human visits.

**Conclusions**

In this paper we have examined the role of tephrochronology in dating earliest Polynesian settlement and impact in New Zealand, the last major landmass to be settled by humans. Despite the exceptional brevity of New Zealand’s prehistory, the suite of multi-sourced tephra layers deposited during this time has provided a valuable tool for correlating and dating archaeological and human-induced palaeoenvironmental events with an accuracy and reliability not previously achieved through radiocarbon dating alone.

Tephra erupted from five North Island volcanic centres of andesitic (Egmont, Tongariro), basaltic (Auckland), or rhyolitic composition (Okataina,
Taupo), together with exotic sea-rafted tephra deposits (Loisels Pumice), are identified as relevant to New Zealand archaeological studies.

(1) Locally-distributed tephras from Rangitoto Island (Auckland) and Mt Taranaki (Egmont) overlie or contain cultural remains and directly date human occupation to c. AD 1400 and 1450, respectively.

(2) Distal andesitic tephras (Tufa Trig Formation members T5 and T8) from Mt Ruapehu (Tongariro) help constrain the timing of onset of human impact signals in Hawke’s Bay to roughly c. AD 1450.

(3) Loisels Pumice, although of uncertain stratigraphic reliability in places, overlies cultural remains that can be no younger than c. AD 1350 on coastlines of eastern North Island.

(4) The widespread Kaharoa Tephra (Okataina), erupted between c. AD 1300–1390, is the pivotal tephra marker bed—the landnám tephra of the southwest Pacific—because no cultural remains are known to occur beneath it and because palynological evidence for earliest human-induced impact, in c. AD 1280 occurs stratigraphically just before its deposition (Figure 2; Newnham et al., 1998b). This maximum date for earliest occupation coincides with the earliest reliable dates for sustained deforestation from other sites in New Zealand (c. AD 1200–1400) and with an earliest settlement date of c. AD 1250–1300 derived from radiocarbon dates from archaeological sites throughout New Zealand (including the oldest known), and therefore supports the late settlement model.

(5) The Taupo Tephra (Taupo), erupted c. AD 200, provides a widespread tephra marker bed currently of ambiguous status regarding New Zealand prehistory. Clearly it provides a benchmark for natural conditions well before (c. 1100 years) the dates for earliest settlement and impact. However, if the Pacific rat-bone dates are confirmed then the eruption of Taupo Tephra would seem to coincide approximately with the proposed early transient contact by humans in New Zealand, and the introduction of a novel predator (Figure 2). The tephra thus provides a convenient marker for a systematic search of the New Zealand coast to test for more definite evidence of early human visits. If there was such contact then it was an ephemeral event (i.e. not settlement) because evidence for any sustained contact is nowhere visible in the archaeological record. Any possible disturbance is indistinguishable from natural background events in the palynological record.

It is evident, despite the advances we have made using tephrachronology, that the precision of the dates on the tephra layers discussed here is limited primarily by the variability in the radiocarbon calibration curves. Even the few early tree-ring dates obtained have been revised in light of new stratigraphic evidence. Consequently, obtaining more precise calendrical dates on the relevant tephras, especially Kaharoa Tephra, either by dendrochronology or from ice-core records (Lowe & Higham, 1998), or other dating techniques, would help to refine assessment of the timing of earliest settlement or impact. Such refinement is essential given the short duration of New Zealand’s prehistory and genetic linkages with other parts of Eastern Polynesia.

Extending the distributional range of critical tephra layers, especially the Kaharoa and Taupo tephras, through the application of crypto- or micro-tephra analyses (Eden & Froggatt, 1996; Newnham et al., 1998b), could lead to a greater understanding of settlement patterns.

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