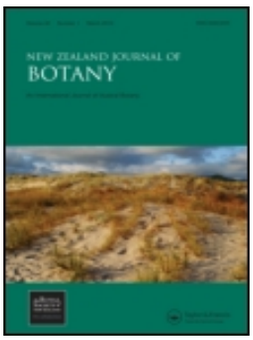

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Identification of Tree Stumps and Driftwood Associated With Tephra Layers in Alluvium, Peat, and Dune Sands

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SUMMARY

From 26 sites in the central and eastern parts of North Island, New Zealand, 37 specimens of wood have been identified botanically and their stratigraphic position established in relation to tephra layers of known age.

Driftwood derived mainly from podocarp trees (*Dacrydium, Podocarpus*) was sampled from five sites associated with old shorelines and river terraces in the Waipaoa River Catchment, and from two sites in the Whakatane River Catchment. The results indicate times at which the corresponding vegetation was growing in the upper parts of these catchments. Stumps between tephra layers sampled from coastal lowlands were mostly from podocarp trees growing *in situ* during the interval 2,100 to 1,800 yr B.P.

The paper also discusses the relationship of earth movements at Gisborne to other events including the Taupo Pumice eruptions, the significance of layers of preserved manuka (*Leptospermum*) in swamps, and changes in the coastline near Whakatane.

INTRODUCTION

Thirty-seven specimens of wood from 26 sites were collected in the Gisborne, Whakatane, Te Puke, Rangipo, Benneydale, and Poukawa localities (Fig. 1). Most specimens were obtained from driftwood exposed in the walls of trenches excavated for sewer and storm water pipes, and from stumps *in situ* in river diversion channels. Also exposed in the trench walls were known and radiocarbon dated tephra layers which were used as marker beds. The trenches and channels provided long sections so the stratigraphic relationship of driftwood and stumps to the associated tephra layers was easily seen.

FIELD AND LABORATORY PROCEDURE

TEPHRA LAYERS

The tephra layers used as marker beds are set out in Table 1.

PLANT MATERIAL

Driftwood was found in alluvium and wave-cast sand inland of the present coast, and stumps and associated fallen logs were found in alluvium, peat, organic mud, estuarine sands, and pyroclastic material. Driftwood was either cast up by the sea, or drifted on to sand banks by rivers. Stumps *in situ* are from trees that once grew on a site, and associated fallen logs are from trees on the same site that were blown over by high winds or eruptive blasts. Other details peculiar to a site are given in Table 2 and Appendix 1.

LABORATORY EXAMINATION

Most samples of geological and archaeological importance sent to the Forest Research Institute belong to the indigenous softwoods. Such wood specimens may be in the form of sound wood, decayed wood, or charcoal. Keys for the identification of these softwoods have been described by Patel (1967a, 1967b, 1968a, 1968b).

The identity of a wood specimen may be determined macroscopically or microscopically. The former method which usually depends on the general appearance of wood, is quite useful when relatively few familiar woods are being dealt with. However the microscopic method is more reliable and has wider application. Thin sections of sound wood for microscopic examination are cut with a microtome knife or freehand with a razor blade. The wood should be kept wet with water or alcohol while it is being cut. Decayed wood and charcoal require impregnation

TABLE 1—Tephra layers and age

Tephra Layer	^{14}C Age (in yr B.P.)	$NZ^{14}C$ No.	Reference
Kaharoa Ash	930 ± 70	10	Fergusson and Rafter, 1955
Taupo Pumice (includes Hatepe Lapilli Member, the first of the Taupo Pumice eruptions)	1819 ± 17 (statistical mean of many dates)	NZGS Bull. 73 p. 32	Healy, 1964
Taupo Subgroup Members (tsg) 9–10	2150 ± 48	1069	Grant-Taylor and Rafter, 1971
Waimihia Formation	3420 ± 70	179	Fergusson and Rafter, 1959
Whakatane Ash	5180 ± 80	1066	Grant-Taylor and Rafter, 1971
Rotoehu Ash	41,700 ± 3500	1126	T. L. Grant-Taylor (pers. comm.)

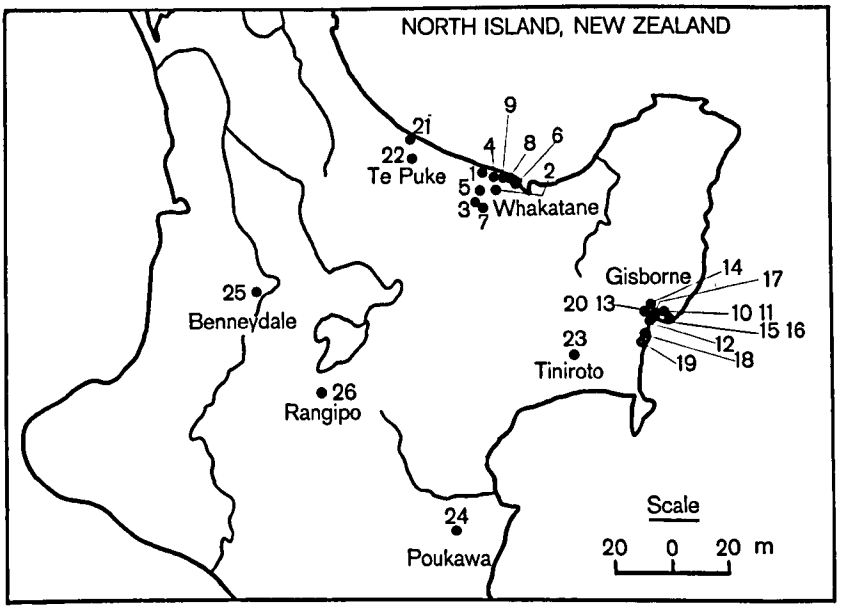

FIG. 1—Location of sample sites.

with paraffin wax or celloidin, to support the fragile cellular structure, before being sectioned. This is a time-consuming process which does not always give satisfactory results. Transverse, tangential longitudinal, and radial longitudinal sections must be cut in order to study the structure and arrangement of the cells.

RESULTS

Results are presented in Table 2.

DISCUSSION

The driftwood found is mainly podocarp wood that has been preserved under anaerobic conditions of high water table. Driftwood on old shorelines is a useful marker in separating the wave-cast sand component from the wind-blown sand component in a dune. In alluvium it may delineate former river courses by indicating a river bank or sand bank. Driftwood is inferred to come from the upland parts of a river catchment (that from Sites 10, 11, 12, 17, and 19 is from the Waipaoa River Catchment and that from Sites 1 and 9 is from the Rangitaiki River and Whakatane River Catchments respectively) (Table 2).

TABLE 2—Identification of tree stumps and driftwood.

Site No.	Collection Date	Map (NZMS 1) Date and Grid Ref.	Locality	Plant Material and Stratigraphic Position	Identification
1.	6.5.67	1967 N68/315283	Thornton, Rangitaiki Plains	Charred driftwood in pumice alluvium overlain by peat and Kaharoa Ash	1. *Podocarpus spicatus* R. Br. ex Mirbel 2. *P. totara* G. Benn. ex. D. Don or *P. hallii* Kirk.
2.	17.11.65	1962 N78/370198	Awakeri, Rangitaiki Plains	Wood in peat between Kaharoa Ash and Taupo Pumice tephra layers, and also between Taupo Pumice and tsg 9-10 tephra layers	3. *Leptospermum* sp., probably *L. ericoides* A. Rich.
3.	27.10.66	1952 N77/255107	Te Mahoe, south of Te Teko	Stump *in situ* buried by Taupo Pumice Alluvium	4. *Dacrycarpus dacrydioides* de Laubenfels
4.	10.5.67	1969 N69/404239	Poroporo, Rangitaiki Plains	Stumps *in situ* covered by Taupo Pumice and alluvium	5. *Podocarpus spicatus* 6. *P. totara* or *P. hallii*
5.	12.7.71	1965 N77/283172	Awakeri, Rangitaiki Plains	Stump *in situ* covered by peat, Kaharoa Ash and Tarawera Ash	7. *Podocarpus* sp., probably *P. hallii*
6.	12.7.71	1969 N69/556213	Ohiwa Harbour	Stump *in situ* covered by Taupo Pumice tephra layer	8. *P. totara*
7.*	1.11.63	1965 N77/266063	Te Mahoe, south of Te Teko	Stump *in situ* in core trench of Matahina Dam. Tephra marker beds absent	9. *P. spicatus*
8.	4.10.63	1969 N69/430240	Whakatane	Stumps *in situ* covered by pumice alluvium	10. *P. totara* 11. *P. spicatus* or *Phyllocladus* sp.
9.	4.10.63	1969 N69/424255	Whakatane	Driftwood in alluvium underneath Kaharoa Ash	12. *Podocarpus spicatus* 13. *Metrosideros* sp. 14. Hardwood
10.	17.7.57	1957 N98/395390	Gisborne	Driftwood in wave-cast sand underneath Waimihia Formation	15. *Dacrydium colensoi* Hook. or *Podocarpus spicatus*
11.	17.7.57	1957 N98/393390	Gisborne	Driftwood in wave-cast sand underneath Waimihia Formation	16. *P. totara*
12.	17.7.57	1959 N98/377383	Gisborne	Driftwood in wave-cast sand between Taupo Pumice and tsg 9–10 tephra layers	17. *Podocarpus* sp.

Site No.	Collection Date	Map (NZMS 1) Date and Grid Ref.	Locality	Plant Material and Stratigraphic Position	Identification
13.	17.5.57	1957 N98/302377	Matawhero, Gisborne Plains	Stump *in situ* covered by tsg 9-10 tephra layer and alluvium	18. *Dacrycarpus dacrydioides*
14.	29.6.69	1965 N98/393293	Gisborne	Wood fragments in organic mud at the base of Rotoehu Ash	19. *Leptospermum* sp.
15.	26.10.57	1965 N98/433328	Sponge Bay, near Gisborne	Charred driftwood in organic mud	20. *Podocarpus* sp.
16.	26.10.57	1965 N98/433328	Sponge Bay, near Gisborne	Stump *in situ* covered by alluvium	21. *Metrosideros* sp.
17.	16.4.57	1957 N98/393390	Gisborne	Driftwood in organic mud below Taupo Pumice	22. *Podocarpus totara* 23. *Laurelia novae-zelandiae* A. Cunn.
18.	19.7.57	1957 N98/309325	Muriwai, Gisborne Plains	Driftwood in alluvium below Taupo Pumice	24. *Dacrycarpus dacrydioides*
19.	16.4.57	1944 N107/302229	Muriwai, Gisborne Plains	Driftwood in alluvium and above Taupo Pumice	25. *Dacrydium cupressinum* Lamb. or *Podocarpus totara*
20.	6.6.70	1957 N98/299385	Matawhero, Gisborne Plains	Stump *in situ* covered by tsg 9–10 tephra layer and alluvium	26. *P. spicatus*
21.	12.12.68	1943 N58/883509	Te Tumu, near Te Puke	Stump *in situ* covered by Taupo Pumice and alluvium	27. *P. spicatus*
22.	6.6.70	1965 N67/818347	Rangiuru, near Te Puke	Wood covered by Rotoehu Ash and Rotoiti Breccia	28. *Nothofagus fusca* (Hook. f.) Oerst.
23.*	6.10.59	1953 N106/935255	Tiniroto, south-west of Gisborne	Stumps *in situ* in organic mud below Whakatane Ash	29. *Podocarpus totara* 30. *P. spicatus*
24.	12.10.68	1952 N141/141054	Lake Poukawa, south of Hastings	Stump *in situ* in loamy peat covered by Waimihia Formation	31. *Dacrycarpus dacrydioides*
25.	3.3.70	1956 N92/864591	Benneydale	Logs covered by Taupo Pumice and alluvium	32. *Nestegis* sp. 33. *Dacrydium cupressinum* 34. *Metrosideros* sp. 35. *Podocarpus totara* 36. *Dacrycarpus dacrydioides*
26.	16.3.70	1970 N112/271894	Pouto Canal, near Rangipo	Stump *in situ* covered by Taupo Pumice	37. *Dacrydium cupressinum*

*Specimens collected from sites 7-13, 15-19 were identified by Messrs J. M. Harris and H. R. Orman; those from sites 23-24 were identified by Messrs R. J. Berry and T. R. Price.

Stumps *in situ* are more valuable in that identification of the wood shows the kind of trees that grew on the site many years ago. The blanketing tephra layer gives a minimum age to the time of growth. For example, Table 2 shows that most specimens (i.e., podocarps) from the coastal lowlands are from trees that grew during the interval 2,100 to 1,800 yr B.P.

Catastrophic destruction of the forest on Gisborne Plains seems to have occurred about 2,100 yr B.P. This date coincides with the formation of Lake Waikaremoana by a landslide (Pullar and Heine, 1971, p. 122) and with the occurrence of earth movements at Gisborne (Site 17, Appendix 1). Earth movements would have induced severe erosion and concominant sedimentation that was thick and rapid enough to kill the trees. Although some dunes at Whakatane were buried by alluvium after this date (Pullar and Selby, 1971, Fig. 1b) it is not known whether earth movements similar to those at Gisborne occurred in the Bay of Plenty region.

In upland basins at an altitude of more than 300 m (Sites 25 and 26) the forest was destroyed by the blast during the Taupo Pumice eruptions. The direction of tree lodgment and the thick Taupo Pumice ash-flow deposit at Rangipo (Site 26) suggest a source for Taupo Pumice near Lake Rotoaira, well away from the accepted source in the Waitahanui locality.

On Rangitaiki Plains (Site 5) dead standing trees were blown over either by high winds or by blast from the Kaharoa eruption. High winds that uprooted hundreds of mature trees ocurred during a severe storm on 9–10 April 1968.

The presence of manuka (*Leptospermum*) twigs and stems in layers in a peat swamp at Awakeri (Site 2) suggests alternate wetting and drying of the swamp land. The most prominent layer occurs between the Taupo Pumice and Kaharoa tephra layers. A similar layer has also been noted in peat swamps in the Waikato Basin where it is known as the "twiggy layer". However in the Waikato its stratigraphic relationship to the Taupo Pumice tephra layer is not known (Tonkin, 1967).

At Ohiwa Harbour, Whakatane and near Te Puke (Sites 6, 4, and 21) stumps *in situ* covered with Taupo Pumice tephra occur at about present sea level. The position of the stumps in relation to sea level suggests that the level was a little lower at the time of the Taupo Pumice eruptions (*c.* 1,800 yr B.P.). At Site 4 buried dunes with Taupo subgroup members (tsg) 9–10 tephra layer (*c.* 2,100 yr B.P.) resting on them have been found at 1.80 m below sea level. The occurrence of these buried dunes at Whakatane and of others near Te Puke indicates that a change in level has occurred between the land and the sea during the interval *c.* 2,100 yr B.P. to *c.* 1,800 yr B.P. The change may have been induced by eustasy or by earth movements as Sites 6 and 21 lie in tectonic basins and Site 4 lies in a graben, but no conclusion is arrived at on the evidence

of stumps and buried dunes alone. Wellman (1962, p.74) thinks the fine grained sediments on the floor of Ohiwa Harbour at Site 6, may have been compacted by earthquakes and that the rise in sea level after the Taupo Pumice eruptions was apparent only.

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APPENDIX 1

Site No.	Notes
1	Wood collected in Taupo Pumice cobbles from pump bay excavated on O. Pedersen's farm; age of wood, 2,230 ± 80 yr B.P. NZ 1353 (T. L. Grant-Taylor, pers. comm.); possibly charred during tsg 9–10 eruption in headwaters of Rangitaiki River and subsequently deposited on Rangitaiki Plains; elevation of wood –2.40 m.
2	Fermah's Road and Rotorua-Gisborne highway; specimens collected at depths of 0.66 m, 0.82 m, 1.05 m, 1.13 m, and 1.50 m from surface; distinct mat of stems (0.03 m diam.) lying flat at 1.05 m from surface; elevation of surface +4.50 m; collected by J. E. Cox.
3	Downstream of Matahina Dam; right bank of Rangitaiki River; waterborne ash derived from Hatepe Lapilli rests on root flange of stump; age of bark from stump 1,995 ± 60 yr B.P. NZ869 (Grant-Taylor and Rafter, 1971); elevation of stump +19.50 m.
4	Diversion channel of Whakatane River excavated 1967-68; stump covered by 3.00 m alluvium; elevation of stump –0.30 m.
5	A. H. Walker's farm, McDonald's Road near intersection with Whakatane-Rotorua highway; tree once grew in soil formed from Taupo Pumice alluvium and was then killed when land became a swamp with the formation of peat; peat mantled with Kaharoa Ash (0.15 m thick) and Tarawera Ash (0.15 m thick) with no break between the two tephra layers; peat deposit at time of European settlement (1908) about 1.50 m thick but with artificial drainage has shrung to 0.30 m thick; logs also noted lying on the peat and mantled with Kaharoa Ash; they were close to the stumps and their position suggests they were once trunks of dead standing trees that were blown over during high velocity winds; direction of tree-lodging mainly north-east; elevation of root flange +13.00 m.
6	Northern side of Ohiwa Harbour 1.21 km east of wharf; on floor of harbour close to coastal dunes; stump in estuarine sand covered at high tide.
7	Stump exposed in core trench during construction of dam for Matahina Hydro Electric Station; in sedimentary beds dipping west at about 20 degrees; bole of stump elliptical with long axis east-west and suggesting compression by earth movements from south to north; sedimentary beds once organic mud but now compacted by compression to a mudstone; distinct paleosol at root flange (Pullar, 1963); stump 10.50 m below present bed of Rangitaiki River and at elevation +12.00 m.

8 Sewer trench in Douglas Street at intersection with Alexander Avenue; tree once grew in grey clay deposited by Whakatane River in swale bordering buried inland dunes; dunes formed *c.* 2,700 yr B.P. to *c.* 2,100 yr B.P. (Pullar and Selby, 1971); root flange covered by waterborne ash derived from Hatepe Lapilli *c.* 1,900 yr B.P. (Pullar and Heine, 1971); root flange 3.30 m from surface and at elevation +1.60 m.

9 Sewer trench in Eivers Road about 0.50 km north of Landing Road; in pumice gravels of Whakatane River alluvium; estuary at time of Taupo Pumice eruptions (Pullar and Selby, 1971); log 1.80 m below Kaharoa Ash and 2.40 m from surface; log lying at mean sea level.

10 Sewer trench in Elm Street; Taupo Pumice and Waimihia Formation at surface; log 1.50 m below surface and at elevation +5.40 m.

11 Sewer trench in Elm Street; Taupo Pumice and Waimihia Formation at surface; log 1.50 m from surface and at elevation +3.90 m.

12 Storm water trench at intersection of Childers Road and Lytton Road; log lying parallel to Taupo Pumice shoreline (Pullar and Penhale, 1970: Fig. 8).

13 Waipaoa River diversion channel; stump buried by 3.00 m alluvium with Taupo Pumice 0.60 m above root flange (Pullar and Penhale, 1970; Fig. 7, p.419); elevation of stump +1.50 m.

14 Right bank Mangapapa Stream at Stout Street bridge; Rotoehu Ash dated at this site >46,300 yr B.P. NZ885 (T. L. Grant-Taylor, pers. comm.); in basal part of this tephra layer are three thin organic mud layers 0.01 m, 0.03 m and 0.34 m thick respectively separating three thin ash layers 0.06 m, 0.03 m, and 0.01 m thick respectively, and all these rest on thick organic mud; the thin organic mud layers are regarded as diastems representing short pauses in the eruption of Rotoehu Ash; specimen collected from the second thin organic mud layer; most likely manuka grew on the thick organic mud and was then smothered by ejectamenta of the Rotoehu Ash eruption; specimen collected 2.80 m from surface and at elevation +6.90 m.

15 Sea erosion has exposed buried forest; log lying at 9.00 m from surface and at about mean sea level; much older than Whakatane Ash which occurs near the surface.

16 Sea erosion has exposed buried forest 9.00 m below surface and at mean sea level; wood appears to have been subjected to severe crushing by earth movements.

17 Sewer trench in Pine Street; at this site several tephra layers and organic mud layers tilted seaward about 3 degrees; tilting occurred before Taupo Pumice eruptions; logs 1.50 m from surface and at elevation +4.50 m.

18 From excavation for No. 4 pier, railway bridge near mouth of Waipaoa River; log 9.00 m below sea level and well below Taupo Pumice which is at sea level.

19 Left bank of Maraetaha River, near mouth; on Maori occupation site; wood 0.84 m from surface and 0.75 m above Taupo Pumice layer; elevation of wood +3.70 m.

20 Waipaoa River diversion channel; right bank 0.35 km downstream of Matawhero bridge; root flange 5.40 m from surface and 2.25 m below Taupo Pumice layer; elevation of root flange +1.05 m.

21 O. L. Brain's farm, Ford Road, bordering old Kaituna River estuary; Taupo Pumice mantles distinct buried soil of dark brown peaty clay loam in which tree once grew; root flange of stump 0.80 m from surface and at mean sea level.

22 Farm track on D. F. Saunder's farm, Maungarangi Road; log lying on paleosol of undifferentiated brown ash resting on ignimbrite; log at 60 m from surface and at altitude 120 m; collected by I. A. Nairn.

23 R. J. Berry's farm; log from tree which once grew on weathered mudstone at base of lake deposits comprising organic mud intercalated with Holocene tephra layers (Vucetich and Pullar, 1964: p.72–3); log dated 6,345 ± 130 yr B.P. NZ427 (Grant-Taylor and Rafter, 1971); lies 1.00 m below Whakatane Ash layer and at altitude of 300 m; collected by R. J. Berry.

24 Drained swamp fringing lake; similar specimen used to date Waimihia Formation 3,270 ± 65 yr B.P. NZ1061 (Grant-Taylor and Rafter, 1971); elevation +20.40 m; collected by T. R. Price.

25 Murcott's farm, Ohirea Road, about 1.61 km north of Benneydale; logs up to 0.90 m diam. lay on a buried forest floor and were mantled by Taupo Pumice tephra 0.60 m to 0.90 m thick; the tephra was then covered by 0.60 m of pumice alluvium derived from the tephra; the buried soil in which the trees grew has distinct u01 and u02 horizons containing fern fronds and tree leaves, and the uA1 horizon has abundant fibrous roots now dead; the uB horizon is gleyed; tephra and alluvium layers moderately well drained; it is thought the trees were blown over during the Taupo Pumice eruptions and the stumps and logs then sealed from the air by the tephra deposit; elevation of buried forest floor about 330 m; collected by J. L. Nicholls and A. E. Beveridge.

26 Pouto Canal, 13.00 km south of Turangi; timber well preserved with bark; covered by Taupo Pumice 15.00 m thick; trees (0.60–1.00 m diam.) with stumps *in situ* blown over by blast during Taupo Pumice eruptions; fallen trunks aligned towards the east and south suggesting blast from the west and north; altitude of stump about 540 m; site inspected by W. A. Pullar, I. A. Nairn, and J. A. S. Dow; collected by W. M. Prebble.