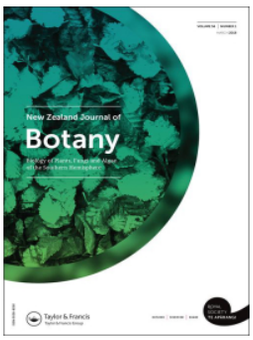

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Identification of Plant Fragments and Pollen from Peat Deposits in Rangitaiki Plains and Maketu Basins

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ABSTRACT

In the Rangitaiki plains and Maketu basins peat deposits, containing dated tephra marker beds (900–5000 yr B.P.), were sampled for plant remains and pollen. The peat is mainly low-moor, sedge peat formed from *Baumea*. In wetter periods *Restionaceae* established, and in drier periods *Leptospermum* and *Gleichenia*.

INTRODUCTION

Basin peat deposits of the Rangitaiki plains and Maketu basins (Fig. 1) contain known and dated tephra marker beds including, in downwards order, Tarawera Ash and Lapilli and Rotomahana Mud, Kaharoa Ash, Taupo Pumice, Taupo Subgroup members 9–10 and 11–13, and Whakatane Ash. Samples of peat were collected from between the marker beds for plant and pollen identification (Fig. 2). Three sites were selected: (1) Fermah Road, Whakatane West, Rangitaiki plains (N78/370197) (1962), (2) K. J. MacDonald's farm, Awakeri, Rangitaiki plains (N68/324222) (1967), and (3) Bell Road, Papamoa, Maketu basin (N58/777533 (1965). Plants mentioned were identified by Campbell and pollen by Heine.

AGE OF MARKER BEDS

Radiometric ages of marker beds in years before 1950 are given as follows:

Tarawera Ash and Lapilli (shortened to Tarawera Ash): Rotomahana Mud AD 1886

Kaharoa Ash: 930±70 (NZ10)

Taupo Pumice: 1840 ± 50 (NZ1548)

Taupo Subgroup members 9–10 (shortened to Tsg 9–10):
from peat above 2010±60 (NZ1068)
from peat below 2150±48 (NZ1069) } c.2100

Taupo Subgroup members 11–13 (shortened to Tsg 11–13):
from peat above 2670±50 (NZ1070)
from peat below 2730±60 (NZ1071) } c.2700

Waimihia Formation (Tsg 14–15): 3440±70 (NZ2)

Whakatane Ash: 5180±80 (NZ1066).

Peat Deposits

At the sampling sites the peat deposits are 4.5 to 6.0 m thick and rest on buried dunes. At Whakatane West and Awakeri the dunes are mantled with Whakatane Ash (Pullar & Selby 1971), so that the dune system was formed after 8000 years ago (no Mamaku Ash present), but before 5000 years (Whakatane Ash present). In the Maketu basin the buried dune system has not been examined closely, but it could well be of the same age as that on Rangitaiki plains. At Whakatane West, the swales in the buried dune system are up to 3 m below present sea level, and this position with respect to the sea suggests either a lower sea level at the time of dune formation, or a sinking of the land by earth movements, or a combination of both. But according to Schofield (1960), the sea level in the Firth of Thames was 2.1 m higher 4000 years ago, so the land on Rangitaiki plains has sunk by about 5 m and the dune system has become drowned. Time of drowning might be gauged by the start of peat formation which has been dated on a buried dune ridge on K. J. MacDonald's farm, Awakeri (N68/333230) (1944) at 3200±65 yr B.P. (NZ1072); dune swales further inland, however, show peat under Rotokawau Ash, undated but thought to be *c.* 4000 yr B.P. Consequently, the beginning of peat formation is assumed to range from 4000 to 3200 years ago.

After the Taupo Pumice eruptions, the Rangitaiki River flood plain was across the Awakeri locality, near Site 2 (Fig. 1). The alluvium here is about 3 m thick and the boundary between the dunes and alluvium is very sharp and at right angles to the dune system, so that the deposition of Taupo Pumice alluvium would accentuate ponding in the dune swales (at Site 2).

The elevation of the peat surface at Whakatane West is +4.5 m, at Awakeri +3.0 m, and in the Maketu basin +4.5 m. Artificial drainage, however, has caused the surface to sink markedly. At Whakatane West drainage was commenced in 1919 and levels taken between 1928 and 1944 show that the land has sunk about 1.5 m, and between 1944 and 1958 about a further 1.0 m. In the Maketu basin the land has not been

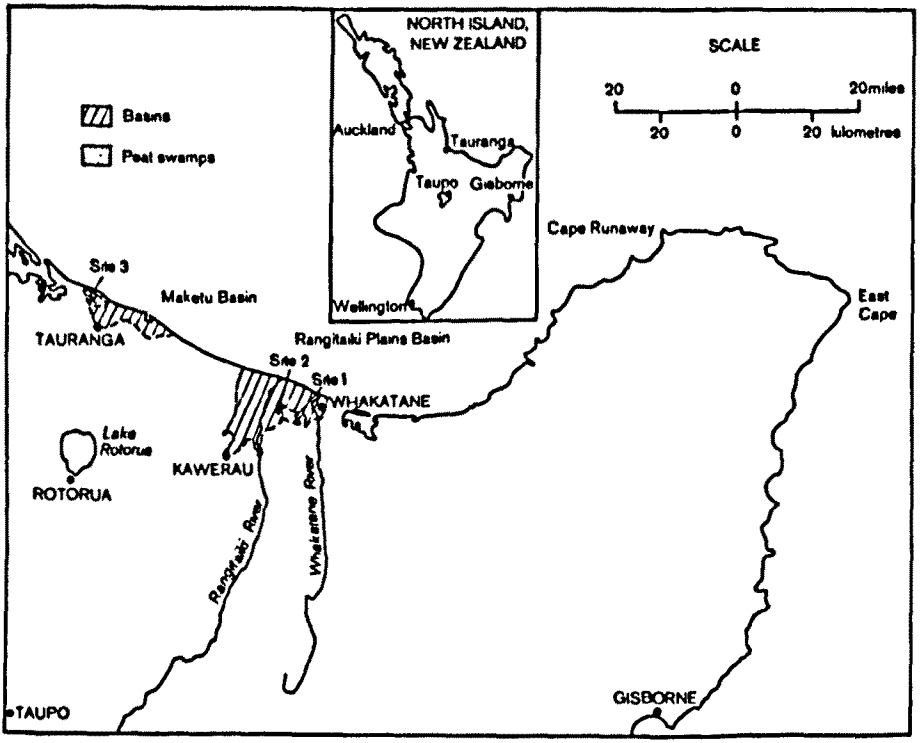

FIG. 1—Sampling sites in Rangitaiki plains and Maketu basins.

as intensively developed for farming as on Rangitaiki plains and so surface sinking is less marked. For example, between 1951 and 1967 the land has sunk 0.3 to 0.6 m. A brief note on early land development for farming at Whakatane West and Awakeri is given in Appendix 1.

The soil formed from the peat deposits is Pongakawa peaty sand.

IDENTIFICATION OF PLANT MATERIAL

The basis for identification of plant fragments is shown in Table 1.

SITE 1

1. Above Tarawera Ash. Soil with no identifiable remains of vegetation.

2. Tarawera Ash to Kaharoa Ash. Brown-black loamy peat with no identifiable remains of vegetation.

3. Kaharoa Ash to Taupo Pumice. For examination this was divided into 4 zones:

A	0–25 cm	C	35–48 cm
B	25–35 cm	D	48–63 cm

TABLE 1—Basis for identification of plant fragments

SPECIES	CHARACTERS USED FOR IDENTIFICATION
Baumea complanata (Bergg.) Blake	root anatomy
Baumea huttonii (Kirk) Blake	root anatomy
Baumea rubiginosa (Spreng.) Boeck.	root anatomy
Baumea teretifolia (R.Br.) Palla	root anatomy
Calorophus minor Hook.f.	root anatomy
Cortaderia toetoe Zotov	root anatomy in transverse and longitudinal sections
Dacrycarpus dacrydioides (Endl.) de Laubenfels	root anatomy in transverse and longitudinal sections and in dissections; xylem tracheids with gymnosperm pitting
Dicksonia squarrosa (Forst.f.) Swartz	root anatomy
Gleichenia microphylla R.Br.	rhizome anatomy, root anatomy, leaf veins, scales, sporangium
Juncus sp.	root anatomy; capsule
Laurelia	anatomy of the roots and the scalariform perforation plates on the oblique end walls of the vessel elements
Leptospermum scoparium J. R. & G. Forst.	root anatomy; structure of bark and xylem
Sporadanthus traversii (F. Muell.) Kirk	root anatomy

DESCRIPTION OF ZONE A: This is a compacted, dry, much decomposed peat in which charcoal layers give evidence of burning. Fine roots of *Cortaderia* run through it. The only recognisable fragments belong to *Baumea complanata, Leptospermum,* and *Gleichenia.*

INFERRED VEGETATION: Shrubs of *Leptospermum* with undergrowth of *Baumea* and *Gleichenia.*

DESCRIPTION OF ZONE B: This is a compact, soft, brownish black peat holding much water. It is basically a sedge peat consisting almost entirely of fragments, roots, and basal tufts of *Baumea complanata.* In places there are a few roots of *Baumea rubiginosa, Leptospermum* (up to 1 cm diameter), *Juncus, Cortaderia, Calorophus,* and of seedling *Sporadanthus,* but all of these play a very minor role. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea complanata* low moor bog with the restiads of raised bog beginning to establish.

DESCRIPTION OF ZONE C: This is a firm, compact, brownish black, sedge peat made as in Zone B almost entirely from *Baumea complanata.* There are a few roots of *Cortaderia, Juncus, Gleichenia,* and *Leptospermum* (up to 1 cm diameter) and an occasional root of *Calorophus.* Another root is considered to be an epacrid root infected with an endotrophic, septate, mycorrhizal fungus. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea* low moor bog with *Cortaderia* and small shrubs of *Leptospermum.*

DESCRIPTION OF ZONE D: This is a firm, compact, brownish black peat. It is basically sedge peat made from the much disintegrated and compacted basal tufts and roots of *Baumea complanata*, but some lengths of *Baumea* root are still clearly recognisable. There are also lengths of *Leptospermum* root (the largest being 3.5 cm in diameter), a few roots of *Cortaderia*, and a few rhizomes and roots of *Gleichenia*. In places there is charred material.

INFERRED VEGETATION: Shrubs of *Leptospermum scoparium* with undergrowth of *Baumea complanata*, and a little *Gleichenia* and *Cortaderia*.

4. Taupo Pumice to Tsg 9–10. For examination this was divided into 3 zones:

A 0–13 cm B 13–25 cm C 25–49 cm

DESCRIPTION OF ZONE A: This is a soft, black, wet peat containing some fibrous material and a few woody pieces. It is basically a sedge peat composed of roots and fragments of *Baumea complanata*, with a little *Baumea rubiginosa* and *B. teretifolia*. Lengths of *Baumea* root in the form of flat strips up to 7 cm long give the peat a stringy appearance. There are also fine roots of *Calorophus*, scattered roots and rhizomes of *Gleichenia*, a few pieces of *Leptospermum* root (diameter 0.2 to 1.5 cm), and a very few roots of *Cortaderia*.

INFERRED VEGETATION: Baumea low moor bog with a little *Gleichenia*, *Leptospermum*, *Calorophus*, and *Cortaderia*.

DESCRIPTION OF ZONE B: For most of its depth this is pure sedge peat formed from *Baumea complanata* and a little *B. teretifolia*. It corresponds to the soft, stringy portion of Zone A and is largely lacking in the fibrous and woody portions contributed by *Gleichenia* and *Leptospermum*. There is a little *Calorophus*. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea* low moor bog establishing after a fire.

DESCRIPTION OF ZONE C: The peat is very like Zone B, being a sedge peat formed mainly from *Baumea complanata*. There is some *B. teretifolia*, a little *B. rubiginosa*, and a few charred fragments. The main distinguishing feature of the zone is the presence of a few, scattered *Leptospermum* roots, including large pieces (4–6 cm diameter).

INFERRED VEGETATION: Tall *Leptospermum* scrub with an undergrowth of *Baumea*.

5. Tsg 9–10 to Tsg 11–13.
DESCRIPTION: This is a soft, brown, wet peat. It is basically a sedge peat formed from fragments, basal tufts, and strips of flattened roots of *Baumea complanata*, and a few roots of *Baumea teretifolia*. Minor components are a few rhizomes and roots of *Gleichenia*, a few pieces of *Leptospermum* root, up to 0.8 cm in diameter, and a very few roots of *Cortaderia* and *Calorophus*. Many charred pieces indicate burning.

INFERRED VEGETATION: *Baumea* low moor bog with some shrubs of *Leptospermum*.

SITE 2

1. Top to Kaharoa Ash. This contains no identifiable plant remains.

2. Kaharoa Ash to Taupo Pumice.

DESCRIPTION: The top 13 cm is very friable, dry, and water repellent. It is a burnt peat as indicated by its structure and the presence of charred fragments. There are no identifiable remains of the plants which formed the peat, but there are fine roots of *Cortaderia* which belong to the post-burn era. The basal 17 cm is a dry, brownish black, compacted peat. It is distinctly laminated and is water repellent. It is basically sedge peat made from *Baumea complanata*, but the material is very fragmented and is also compressed as if subjected to heavy pressure from above. There are short lengths of *Dacrycarpus* roots, including nodulated ones,, 0.01–0.02 cm in diameter, and non-nodulated ones up to 0.1 cm in diameter and a few roots of *Cortaderia*. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea* low moor bog with a few small plants of *Dacrycarpus*.

3. Taupo Pumice to Tsg 9–10.

DESCRIPTION: This is a rather dry, brownish black, gritty peat which in some parts is friable and in other parts compacted. It is basically a disintegrated sedge peat derived from *Baumea complanata*, but only a few fragments of this plant are still recognisable. There is also a fibrous component consisting of roots of *Sporadanthus*, a few roots of *Cortaderia*, and fine roots of *Calorophus*. Small charred fragments indicate burning.

INFERRED VEGETATION: *Baumea complanata* of low moor bog being replaced by the restiads, *Calorophus and Sporadanthus*, of raised bog.

4. Tsg 9–10 to Tsg 11–13.

DESCRIPTION: This is a firm, compacted, wet, black peat. At the top it is basically a sedge peat made from fragments, basal tufts, and roots of *Baumea complanata*. Frequently the tufts are charred. It contains also roots of young *Sporadanthus*, a few of *Calorophus*, *Baumea huttonii*, *B. rubiginosa*, *B. teretifolia*, and a very few of *Cortaderia*. In the middle there is a compacted sedge peat made from *Baumea complanata*, *B. huttonii*, and *B. rubiginosa*. There are also a few lengths of *Gleichenia* rhizome, roots of young *Sporadanthus*, and a little *Calorophus*. Charred fragments indicate burning. At the base there is a compacted sedge peat composed partly from *Baumea complanata*, but containing also fragments and roots of *B. huttonii*, *B. rubiginosa*, *and B. teretifolia*. There are a few roots of rushes.

INFERRED VEGETATION: Incipient raised bog with Restionaceae coming in and replacing the low moor *Baumea* species of the lower layers.

5. Tsg 11–13 to the Waimihia Formation. For examination this was divided into 2 zones:

A 0–15 cm B 15–30 cm

DESCRIPTION OF ZONE A: This is a rather firm, black, wet peat. It is basically a sedge peat made from fragments, basal tufts, and long strips (up to 7 cm) of flattened root of *Baumea complanata*. Embedded in the peat are long pieces of woody root, *Leptospermum* (4 cm diameter), *Laurelia* (1.5 cm diameter), and a small piece of *Dracophyllum* (1 cm diameter). Very minor components are roots of *Cortaderia*, *Calorophus*, and *Sporadanthus*, rhizomes of *Gleichenia*, a fragment of *Dacrycarpus* wood, and short lengths of *Laurelia* root. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea* low moor bog with a few shrubs and dwarfed, swamp-forest trees. Restiads indicative of raised bog are beginning to establish.

DESCRIPTION OF ZONE B: This is a soft, wet, brown peat which is largely disintegrated to single cells and fragments, but contains also a woody component and some charred material. It is basically a sedge peat consisting of fragments, basal tufts, and roots of *Baumea huttonii* and larger roots of *B. complanata*. There are a few detached root nodules of *Dacrycarpus* and a large piece of *Dacrycarpus* root (6 × 11 cm). A few roots of seedling *Sporadanthus* are intact and there are charred bases of slightly larger plants. Very minor components are roots of *Cortaderia* and stems of the moss, *Dicranoloma billardieri*.

INFERRED VEGETATION: *Baumea* low moor bog with scattered *Dacrycarpus* and a few seedlings of *Sporadanthus*.

6. Waimihia Formation to Whakatane Ash. For examination this was divided into 3 zones:

A 0– 25 cm B 25– 50 cm C 50–120 cm

DESCRIPTION OF ZONE A: This is a brown, fibrous, dry peat which in some places is firm and compacted and in other places is friable. It is a burnt sedge peat. Much of the material occurs as small fragments, but some roots of *Baumea complanata* are still recognisable. There are a few pieces of *Dacrycarpus* bark, a few fine roots and some sheets made of compacted leaf sheaths of *Cortaderia*, and a few brown roots which resemble those on the trunk of the tree-fern, *Dicksonia squarrosa*.

INFERRED VEGETATION: *Baumea* low moor bog with a little *Cortaderia* and *Dacrycarpus*.

DESCRIPTION OF ZONE B: This is a very soft and very wet, brown peat containing much charred material. It is basically sedge peat derived from *Baumea complanata*, for a few roots of this plant are still recognisable. But it also contains fragments of bark and many roots of *Dacrycarpus*. The latter range in size from a large piece (4 × 42 cm) to nodulated roots (0.1 cm diameter).

INFERRED VEGETATION: *Baumea* low moor bog with dwarf trees of *Dacrycarpus*.

DESCRIPTION OF ZONE C: This is very similar to Zone B. It is basically sedge peat and contains charred material. It is mostly disintegrated to single cells and small fragments, but some lengths of *Baumea complanata* root are still recognisable. There are many detached root nodules, as well as nodulated fine roots, and also larger roots of *Dacrycarpus*, including a piece 1.5 ×27 cm and another 2 × 8 cm.

INFERRED VEGETATION: *Baumea* low moor bog with dwarf trees of *Dacrycarpus*.

SITE 3

1. Top to Kaharoa Ash. This contains no identifiable plant remains.

2. Kaharoa Ash to Taupo Pumice.
DESCRIPTION: The peat is very friable, dry, and water repellent. It consists mainly of single cells but there are some brownish, non-nodulated *Dacrycarpus* roots (up to 0.4 cm diameter) and fine white roots of *Cortaderia*.

INFERRED VEGETATION: *Baumea-Cortaderia* low moor bog with dwarf trees of *Dacrycarpus*.

3. Taupo Pumice to Tsg 9–10.
DESCRIPTION: The peat is very friable, dry, and water repellent. It consists largely of single cells, but there are also brownish, non-nodulated roots of *Dacrycarpus* (up to 0.2 cm diameter), numerous fine, whitish roots of *Cortaderia*, dark-coloured rhizomes and roots of *Gleichenia*, and a few roots belonging to *Baumea complanata* and *B. rubiginosa*.

INFERRED VEGETATION: *Baumea-Cortaderia* low moor bog with some *Gleichenia* and dwarf *Dacrycarpus*.

4. Tsg 9–10 to Tsg 11–13. For examination this was divided into 3 zones:

A	0–10 cm	B	10–15 cm	C	15–30 cm

DESCRIPTION OF ZONE A: This is a soft, wet, but friable, sedge peat, not easily rewetted after drying. It consists mainly of single cells and small fragments, but there are also rhizomes, roots, and many leaf veins of *Gleichenia*, basal tufts and roots of *Baumea complanata* and *B. rubiginosa*, roots of *Cortaderia*, roots of *Laurelia* (up to 0.2 cm diameter), and a few roots of *Dacrycarpus* (up to 0.1 cm diameter) and *Calorophus*. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea* low moor bog with *Gleichenia*, dwarf trees of *Laurelia* and *Dacrycarpus*, and a little *Calorophus*.

DESCRIPTION OF ZONE B: This is a twiggy layer composed mainly of roots, rhizomes, and leaf veins of *Gleichenia*, roots of *Laurelia* (up to

1.5 cm, but usually 0.4–0.5 cm in diameter), basal tufts and roots of *Baumea complanata, B. rubiginosa,* and *B. teretifolia,* and fine roots of *Calorophus* and *Cortaderia.* Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea-Gleichenia* low moor bog with dwarf trees of *Laurelia,* and some *Calorophus* and *Cortaderia.*

DESCRIPTION OF ZONE C: This is a soft, brown, sedge-fern peat, not readily wetted after drying. It consists mostly of short fragments and single cells, including fine roots of *Calorophus.* It also contains a fibrous component made up of roots, rhizomes, and leaf-veins of *Gleichenia,* roots of *Baumea complanata, B. huttonii, B. rubiginosa,* and *B. teretifolia,* fine roots of *Cortaderia,* and non-nodulated roots of *Dacrycarpus* (up to 0.5 cm in diameter). There is a greater proportion of *Dacrycarpus, Gleichenia,* and *Baumea complanata* immediately overlying Tsg 11–13. Charred fragments indicate burning.

INFERRED VEGETATION: *Baumea-Gleichenia* low moor bog with *Cortaderia,* dwarf trees of *Dacrycarpus,* and *Calorophus.*

5. From Tsg 11–13 down.
DESCRIPTION: This is a fibrous, twiggy, fern peat composed mainly of *Gleichenia* roots, but there are also rhizomes of *Gleichenia,* roots of *Baumea complanata, B. huttonii, B. rubiginosa,* and *B. teretifolia,* a few pieces of *Laurelia* root (diameter up to 1.5 cm), and occasional fine roots of *Cortaderia, Calorophus,* and *Dacrycarpus.* Charred fragments indicate burning.

INFERRED VEGETATION: *Gleichenia* low moor bog with a little *Baumea,* dwarf trees of *Laurelia* and *Dacrycarpus,* and a little *Cortaderia* and *Calorophus.*

POLLEN ANALYSIS FROM SITE 1

SAMPLING AND EXTRACTION

Samples for pollen analysis were collected from Site 1 to a depth of 170 cm, about 10 cm below the Tsg 9–10 bed (Figs 2, 3). The analysis, therefore, covers a time span of approximately 2100 years.

Samples were taken using a core sampler (2.5 cm diameter) in an attempt to obtain constant volume, every alternate 2.5 cm. Extraction of pollen was carried out using KOH and acetolysis procedures. Samples containing ash had HF treatment before they were examined.

Results from samples which had low pollen counts are not used. Low pollen counts were obtained from samples of twiggy or leafy layers and are probably related to variations in the density of the peat.

Fig. 3 shows the results, expressed as percentages, of pollen analysis for the site.

SOURCE OF POLLEN AND SPORES

Local sources, i.e., sources from vegetation on and about the site, are inferred for sedge, restiad, *Leptospermum* pollen, and fern spores because identifiable remains of these plants occur in the profile, and for grass and weeds which are the present-day vegetation at the site. Nevertheless, the pollen sum for these plants will include some external contributions.

Distant sources, i.e., from vegetation living about and beyond the site, are inferred for Podocarpaceae, *Nothofagus*, *Metrosideros*, and most other dicotyledonous shrubs and trees, because the pollen is known to be wind-transported. They account for only a small percentage of the total pollen sum, and no identifiable remains of the plants they represent are recorded in the peat. Podocarpaceae form a more or less constant part of the pollen profile throughout its whole depth.

DIVISIONS OF POLLEN PROFILE

1. Above Tarawera Ash

This layer was not sampled for pollen because the peat is powdery and loose, conditions which are poor for preservation of pollen.

2. Tarawera Ash to Kaharoa Ash

Pollen from herbaceous species dominate this part of the profile, particularly grass and weed pollen which decreases downwards. *Pteridium* spores increase to a maximum at 13–16 cm and then decrease. Podocarpaceae pollen is low in samples from the upper part but increases downwards. All pollen grains are poorly preserved and hard to identify because farm practices such as draining and cultivation have caused breakdown of the pollen.

3. Kaharoa Ash to Taupo Pumice

For examination, this section of the profile was considered in four zones which grade from one to the other and are only approximate to the zones based on identified plant material. Podocarpaceae pollen is more or less constant down this section of the profile.

A. Sedge and restiad pollen increases as does *Leptospermum*, down the profile.
B. Restiad pollen and *Gleichenia* spores constitute about 48% of non-tree pollen (NAP) which becomes dominant in this part. *Leptospermum* decreases, then begins to increase, down the profile.
C. Tree pollen percentage (AP%) reaches its maximum for this profile and it is dominated by *Leptospermum* pollen. Dicotyledonous shrubs and trees show a wide range of genera. Sedge and restiad pollen has decreased.
D. Tree pollen percentages, especially that of *Leptospermum*, decreases sharply immediately after deposition of the Taupo Pumice; Podocarpaceae pollen remains constant, indicating that forest on surrounding hills was probably not affected much by the ash shower. Restiad pollen increases and *Gleichenia* spores are present.

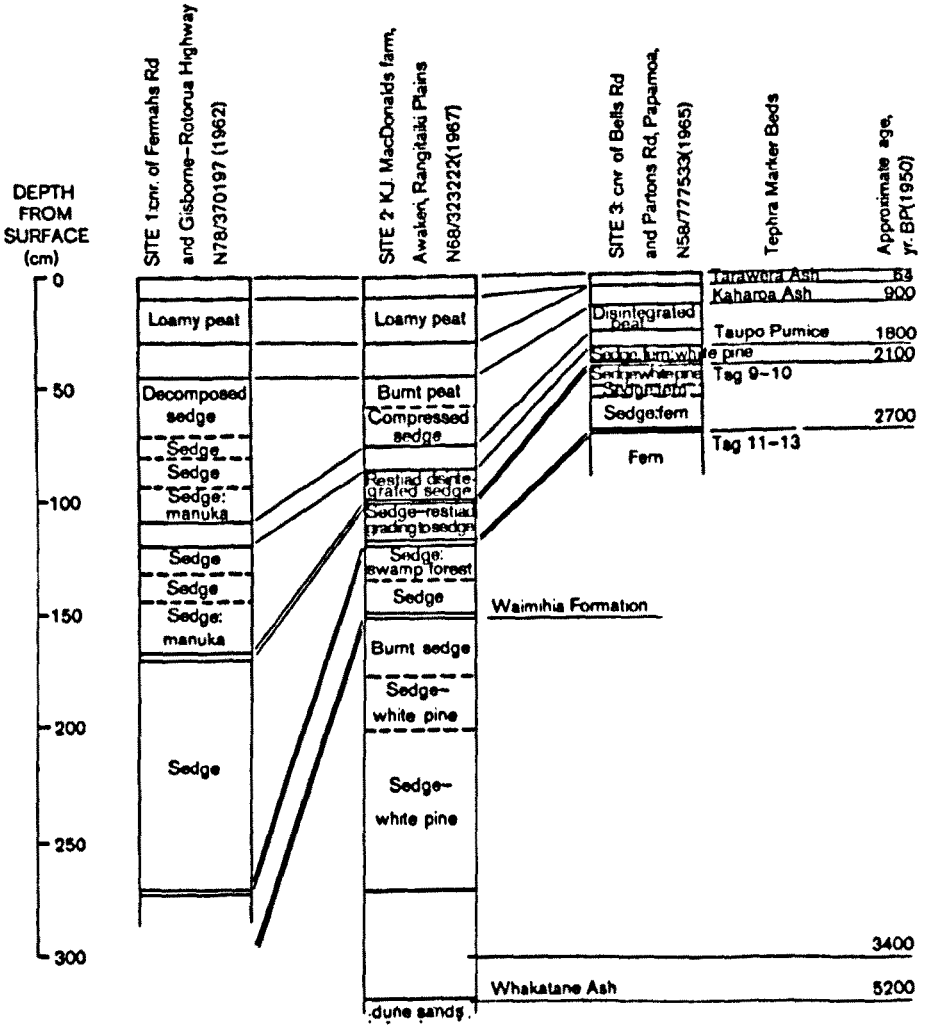

FIG. 2—Sections in peat swamps of Rangitaiki plains and Maketu basins showing tephra marker beds, kind of peat, and age of peat formation.

4. Taupo Pumice to Tsg 9–10

This layer was considered in three zones which grade from one into the other and are roughly approximate to the zones based on identified plant material.

A. Restiad pollen dominates and sedge pollen decreases. *Leptospermum* is initially quite high, but decreases downwards.
B. Sedge pollen increases then decreases while restiad pollen decreases then increases. Podocarpaceae are increasing.
C. Sedge pollen dominates and restiad pollen decreases with % non-tree pollen being dominant. *Leptospermum* and other tree pollen,

including Podocarpaceae, decrease immediately above the Tsg 9–10 bed.

5. Tsg 9–10 to 175 cm depth
As only two of the three samples collected are useful, the pollen analysis is not reliable for interpretation. Sedge, then restiad pollen dominates; tree pollen, particularly *Leptospermum*, however, decreases.

Discussion

From a study of plant remains (mainly roots), pollen, and fern spores preserved in the peat it is possible to construct a picture of the past vegetation in the bog areas on the Rangitaiki plains. This cannot be completely accurate for some roots, e.g., *Cortaderia* and *Laurelia*, are relatively very resistant to decay; fires have been frequent as indicated by the presence of charcoal in almost all the layers, and some pollen has drifted in from vegetation on the surrounding hills. Obviously, too, a more complete picture would be obtained by sampling from additional sites on the plains.

However, we can conclude that the peat for the most part is a sedge peat which has developed in low moor bogs with *Baumea complanata* as the main peat-former. There would be free water around the *Baumea* clumps and around the taller clumps of *Cortaderia* which is often present. There were drier periods when *Gleichenia*, *Leptospermum*, *Dacrycarpus*, *Laurelia*, and, no doubt, associated plants tended to establish and wetter periods when the restiads (*Calorophus* and *Sporadanthus*), indicative of raised bog, came in. It is not surprising to find no trace of *Sphagnum*, a light-demander, considering the density of the taller plants.

Site 1.

Most detail is available for Site 1, for here both plant remains and pollen were studied. The results show that for most of the period there was a bog vegetation of *Leptospermum*, *Baumea*, Restionaceae, and *Gleichenia*. Among the pollen is a small proportion of tree pollen interpreted as being wind-drifted from surrounding hills, because it is light pollen with air sacs.

Beginning at the top we find that between the Tarawera Ash and the Kaharoa Ash no roots are preserved. The pollen profile shows a vegetation of pasture grasses and weeds (*Taraxacum* and *Cirsium*), and indicates cultivation of the soil following draining and burning of the area. The *Pteridium* peak may reflect a bracken cover in place of forest on neighbouring hills.

Between the Kaharoa Ash and the Taupo Pumice, both the pollen profile and the plant remains show that Restionaceae are prominent towards the upper part of this section, indicating an incipient raised bog with water of telluric origin being retained by impeded drainage. This follows a period of drier soil when *Leptospermum* flourished. The pollen

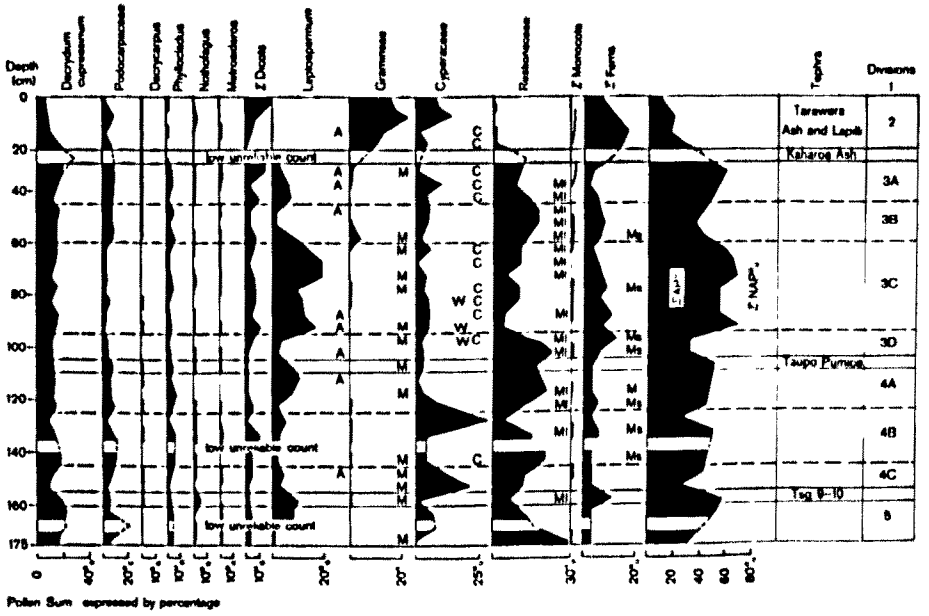

FIG. 3—Pollen diagram, expressed in percentages, of peat from Site 1, Rangitaiki plains

A *Ascarina*
M *Melicytus*
C *Coprosma*
Ml *Muehlenbeckia*
Ms *Myrsine*
W *Weinmannia*

profile shows a further alternation of Restionaceae and *Leptospermum* towards the base of the section, but this is not obvious in the peat where the roots of *Calorophus* appear to make little contribution under the low moor conditions.

Between the Taupo Pumice and Tsg 9–10 the pollen profile shows marked alternation of peaks of sedge (? *Baumea*) and Restionaceae indicating drier and wetter conditions. Such information is unobtainable from remains of plant roots which penetrate through a depth of several centimetres in the peat. Between Tsg 9–10 and Tsg 11–13 the results, though incomplete, indicate a similar alternation of drier and wetter conditions.

SITE 2.

Above the Kaharoa Ash at site 2 the soil reflects the effects of farming. Between the Kaharoa Ash and the Taupo Pumice the peat is likewise greatly altered, but can be recognised as sedge peat. *Dacrycarpus* roots in the peat probably belong to short-lived, seedling trees. Between the Taupo Pumice and Tsg 9–10 the presence of *Sporadanthus* indicates very wet, raised-bog conditions and impeded drainage. Similar raised-bog vegetation occurs immediately below Tsg 9–10 but then gives way to low-moor *Baumea* species, indicating better drainage. Below Tsg 11–13 and extending to the Whakatane Ash the presence of woody roots in the

peat suggests that at the time the site may have been adjacent to a lagg* area.

SITE 3.

Above the Taupo Pumice at site 3 the peat has been greatly altered by farming. Between the Taupo Pumice and Tsg 9–10 there is a low-moor, sedge-fern peat with a few roots of *Dacrycarpus* which probably belonged to short-lived seedlings. Between Tsg 9–10 and Tsg 11–13 the low-moor peat has a peculiar component consisting of leaf-veins of *Gleichenia*. Since above-ground parts are rare elsewhere in the peat, it is suggested that the area suffered sudden and prolonged submergence such as occurs in the formation of a lake. The presence of roots of seedling trees suggests proximity to a lagg, whose outlet may at some time have become blocked. Below Tsg 11–13 the peat is also peculiar as it consists almost entirely of *Gleichenia* roots. This suggests rather dry conditions prior to the deposition of the ash.

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APPENDIX 1

EARLY LAND DEVELOPMENT HISTORY AT WHAKATANE WEST AND AWAKERI

At Whakatane West, land was obtained from Maori owners by the Yeoman family in 1917, but it could not be farmed until Yeoman's Drain was dug in 1919. At that time the ground was hummocky, with small domes 5 to 6 m across, and covered with wiwi rush. The hummocky parts could be walked on, but if jumped on, it was easy to fall through the peat to knee depth. To prepare the ground for tilling, a Samson tractor with three lattice-rollers was employed, and after drainage and consolidation the land was disced using horse traction.

At Awakeri, Mr Alan Barr said that in 1912 the vegetation was largely manuka, and the peat surface sufficiently safe for him to gallop a horse through the scrub. In early 1960s, stumps 0.7 m high were seen protruding through the ground, and it would be decidedly risky to gallop across the land today. Mr Barr's neighbour, the late Douglas Allan, had said his farm was almost wholly in peat and peat-fires were common in summer. He thought the land had sunk about 1 m.

*Brook or fen encircling the bog.