Establishing long-term changes in takahē winter feeding grounds in Fiordland using pollen analysis

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CONTENTS

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ABSTRACT

The relict population of takahē (*Porphyrio hochstetteri*) was rediscovered in the Murchison Mountains, Fiordland, New Zealand in 1948, about the same time that invading introduced deer were reaching their peak numbers. Although much is known about deer diet, and about takahē diet in the alpine areas they currently occupy, little is known about takahē diet in the forests and even less on what the forest understorey was like before deer invasion. Deer and takahē share the Murchison Mountains forest habitat, particularly in winter when snowfall forces the birds into the forest for food and shelter. This study uses high-resolution pollen analyses of short peaty cores from under the beech forest canopy in the Chester Burn catchment in the Murchison Mountains, to show how the forest understorey has changed significantly over at least the last 1000 years, but particularly over the last 50 years since deer invasion. In terms of preferred taxa in the takahē diet, over the last 50 years sedges, grasses, and *Celmisia* spp. have all become less common than they were in the past, and some species of ferns such as *Polystichum vestitum* and *Hypolepis millefolium* are strikingly more abundant. Present-day takahē diet in the Murchison Mountains may not be typical of their diet in the past; they may have fed in the forest habitat more often when there were more bush grasses available. Deer browsing is the most likely cause of these relatively recent changes in forest understorey composition. A depleted understorey and ground flora may limit takahē winter diet, and affect the condition of the birds at the end of winter, and their survival or reproductive capability.

Keywords: deer browsing, Fiordland, forest disturbance, New Zealand, *Porphyrio hochstetteri,* pollen, soil cores, takahē, understorey

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1. Introduction

The takahē (*Porphyrio hochstetteri*) along with the kākāpō (*Strigops habroptilus)* are the only members of a guild of large, flightless endemic herbivorous birds that survived the impact of human settlement in New Zealand. Until the takahē was rediscovered in 1948, this bird was thought to be extinct, and has since been the focus of major conservation effort to boost its population size and range (Mills et al. 1982; Crouchley 1994). Although the takahē was formerly widely distributed throughout New Zealand (Mills et al. 1984; Beauchamp & Worthy 1988), human modification of the vegetation and introduced predators have reduced the relict population to a small area in Fiordland National Park, now known as the Takahē Special Area in the Murchison Mountains. The total population of takahē in New Zealand is 214 adult birds, of which 141 inhabit the Takahē Special Area, 59 in separate populations on Maud, Mana, Kapiti and Tiritiri Matangi islands and the rest in breeding programmes or wildlife parks (Lee & Jamieson 2001).

In the Murchison Mountains the takahē inhabit the alpine and subalpine snow tussock grasslands during snow-free periods, where they feed predominantly on the fleshy basal meristems of *Chionochloa pallens, C. flavescens, C. crassiuscula, C. rigida, Celmisia petriei* and smaller grasses, sedges and rushes (Mills & Mark 1977; Mills et al. 1984). During harsh winters when the alpine tussocks are covered in thick snow, takahē move down into the *Nothofagus* forest for food and shelter. During such periods, takahē eat grasses and sedges growing on wetlands and small clearings in the forest and valley floors, and supplement these with the grubbed up, starch-rich rhizomes of *Hypolepis millefolium* (Mills et al. 1980). Harsh winters with prolonged periods of snow-lie above the tree line may contribute to higher takahē mortality rates (Maxwell & Jamieson 1997). An impoverished understorey and ground flora may limit takahē winter diet, affecting their condition at the end of winter (Mills et al. 1980). However, the importance of the beech forest as winter habitat for takahē is poorly understood (Maxwell 2001).

Since red deer (*Cervus elaphus)* and wapiti (*C. e. nelsoni*) invaded the Murchison Mountains in the 1930s and 1940s, with numbers of deer peaking in the 1950s (Mills & Mark 1977; Parkes et al. 1978), the same habitat has been significantly altered by selective browsing (Wardle et al. 1971). Mills & Mark (1977) identified that deer overlapped and competed with takahē in both their preferred habitat and diet, particularly among tussock grasslands above the tree line (c. 1110 m). As part of the initial takahē conservation effort, culling measures began in the late 1940s, intensified in the 1960s and eventually reduced the deer population by the 1980s to relatively stable numbers (Parkes et al. 1978; Maxwell 2001). Effective helicopter hunting began in 1975 and altered deer behaviour, forcing the remaining population into the forests (Nugent et al. 1987). While this relieved the alpine tussock grassland from intensive grazing pressure (Rose & Platt 1987) palatable species continued to be browsed in the forests and clearings below the tree line. Although the Fiordland vegetation has been monitored through repeated measurements of vegetation plots set up in 1969 (Burrows et al. 1999) these only provide 30 years of vegetation history and do not extend to the time before deer invasions in the area. Although current diets of deer and takahē in the forest only overlap to a limited extent (Maxwell 2001), it is not known if selective deer browsing over time has removed or severely depleted species from forests that may have been important takahē habitat or food in the past, or at the least, indirectly affected takahē diet through alteration of the understorey composition. Deer browsing may have left takahē with severely impoverished dietary options in the forest, which may be particularly critical for their survival during harsh winters.

Although recent changes to the Murchison Mountain forests have been interpreted from permanent plot data, the period covered is very short in the life of the forest. The surveys may only show the trajectory of a depleted vegetation in the process of recovery after heavy infestations of deer. Little is known about the forest composition before the deer arrived, yet this information could make a vital contribution to the understanding and management of current takahē populations. This study attempts to provide a longer term perspective on forest composition in one of the valleys in the Murchison Mountains for at least the last 1000 years before deer invasion. The high-temporal-resolution vegetation reconstruction is achieved through detailed pollen analysis of peaty soil cores taken from under the forest canopy in areas where takahē have been seen. The work is exploratory and attempts to use a novel technique to contribute new information to one aspect of the conservation of the takahē.

2. Background

All samples were collected from the Chester Burn catchment in the Murchison mountains (Fig. 1) from areas where takahē have been observed (J.M. Maxwell, pers. comm.). The areas sampled consisted of forests dominated by *Nothofagus menziesii* (silver beech) from the tree line down to the valley floor at 600 m, with varying amounts of *Nothofagus solandri* var. *cliffortioides* (mountain beech). The composition and structure of the forest in the Murchison Mountains is described in detail by Wardle et al. (1971), and analyses of changes over the last 30 years derived from permanent plot data are reported in Burrows et al. (1999).

The Chester Burn is typical of other valleys in the Murchison Mountains, in that it is a deeply dissected and eroded postglacial landscape, with cirques, rugged tops, steep-sided valley walls, and aggraded valleys with outwash alluvium, and the highest peak rising to 1620 m at the head of the valley. The rocks are predominantly hard, grey to pale-green dioritic gneisses, and the low-fertility forest soils are classified as Titiraurangi, ranging from a fibrous peat to a peaty loam overlying a sandy loam over rock (New Zealand Soil Bureau 1968). The climate of the area is typified by high precipitation throughout the year (c. 5000 mm) falling as rain mostly during the summer months, and snow above c. 900 m during the winter (Sansom 1984). The prevailing winds are moisture-laden westerlies.

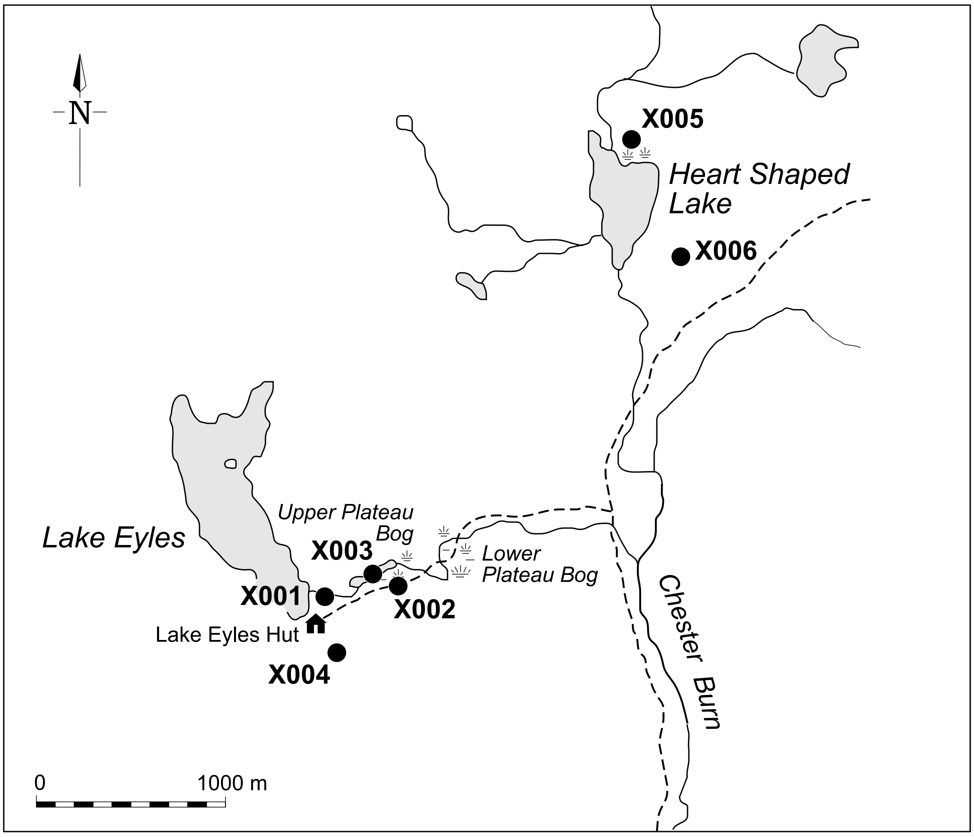

Figure 1. Map of Lake Eyles (45°14′S 167°28′E), Chester Burn and the coring site locations.

3. Objectives

- To pollen-analyse two peat cores collected from underneath the forest canopy in the Chester Burn catchment, Murchison Mountains, to reconstruct the vegetation for at least the past 100–1000 years.
- To identify any changes in the forest understorey composition, particularly potential takahē food, i.e. grasses, sedges and ground ferns, during this period.

4. Methods and site/sample descriptions

4.1 SAMPLE COLLECTION

One week was spent in the Chester Burn catchment collecting samples in February 2000. Six 50-cm-deep soil cores were collected from various sites (see Fig. 1 and Table 1 for details) in the Chester Burn catchment, Takahē Special Area, Fiordland. Three were from poorly drained hollows directly under a forest canopy, and two from open *Sphagnum* bogs. All cores were described in the field, and sub-sampled in the laboratory for pollen analysis.

In this study, two of the soil cores collected (X00/2 and X00/4) are analysed for pollen. Although these coring sites were both small open clearings with light penetrating to the ground surface, they were not merely gaps caused by the death of canopy trees. The hollows appear to have been poorly drained sites for several millennia at least, and have relatively deep accumulations of highly organic peat soils, which consist mostly of *Sphagnum* leaf remains. The better-drained soils of the forest floor adjacent to the hollows are thinner and more mineral rich.

4.2 FOSSIL SAMPLES

Details regarding all the coring sites for soil cores are presented in Table 1. More-detailed information about the two cores selected for detailed pollen analysis is given below, along with descriptions of the vegetation surrounding the coring sites.

4.2.1 Site description for core X00/2 Eyles Upper Plateau Bog–forest margin

The site is 4.5 m from the margin of the Eyles Upper Plateau Bog (Fig. 2; see Fig. 1 for map location), the core was taken under the forest canopy. Canopy 15 m, *Nothofagus menziesii*—up to 35 cm dbh; 90% *Nothofagus menziesii*, occasional mountain beech, some *Hoheria glabrata* nearby. The understorey was dominated (20%) by small-leaved coprosmas (*Coprosma* spp.) up to 2.5 m high, and *Pseudopanax colensoi* up to 2 m, which were also abundant on the ground as seedlings. Occasional *Raukaua simplex, Myrsine divaricata,* and *Olearia colensoi* were scattered in the bush margin.

On the ground *Astelia nervosa* and *Polystichum vestitum* made up 50% cover, with occasional *Nothofagus menziesii* and *Phyllocladus aspleniifolius* var. *alpinus* seedlings (but only a few <2 m adult specimens seen around the bush edge). Mosses mainly dominated the forest floor with *Uncinia*, *Blechnum penna-marina,* and *Hymenophyllum* on logs. There was abundant light getting through to the ground.

Soil depth in this coring site was over 120 cm. The core was dug out of the ground to a depth of 45 cm. Small roots were abundant in the top 30 cm. *Sphagnum* peat deposits continued below our maximum sampling depth down to the base. The core was sampled contiguously every 1 cm.

X00/2 stratigraphy

0–7/10 cm	unhumified moss
7/10–20 cm	dark brown soily peat with charcoal and roots, *Nothofagus menziesii* twigs
20–46 cm	poorly humified *Sphagnum* peat.

TABLE 1. CORE DETAILS (CORES HIGHLIGHTED IN BOLD ANALYSED IN THIS STUDY).

CORE	LOCATION	GRID REFERENCE NZMS SHEET C42	ELEVATION (m a.s.l.)	BRIEF SITE DESCRIPTION	MAX. DEPTH (cm)	DEPTH OF CORE SAMPLE (cm)	CORE MATRIX	ASSOCIATED SURFACE SAMPLES
X00/1	Above Lake Eyles hut—tarn margin	765 357	1030	Bog filled depression at tree line in morainic debris—edge of tarn	120	45	Humified red-brown peat	X00/7/SS4
X00/2	Eyles upper plateau bog—forest margin	769 359	880	Under silver beech forest canopy about 5m from upper plateau bog margin	>120	45	*Sphagnum* peat	X00/7/SS3
X00/3	Eyles upper plateau bog	768 358	880	Open *Sphagnum* bog with tussock grasses and sedges	>120	50	*Sphagnum* peat	
X00/4	Top of Lake Eyles track—below hut	766 355	990	Small *Sphagnum* clearing under silver beech canopy	66	50	*Sphagnum* peat	X00/7/SS8
X00/5	Heart Shaped Lake—edge, abundant deer hoof prints seen in the area	782 382	600	*Sphagnum*-peat-covered silt fan—indentation in mountain beech along wetland margin	40	40	*Sphagnum* peat	X00/7/SS11
X00/6	Upper Chester Burn forest hollow	784 375	635	Tree-fall clearing in silver beech forest on plateau ridge	>120	40	Peaty soil with lenses of gneiss fragments	X00/7/SS12

Figure 2. Coring site X00/2, Upper Plateau Bog.

4.2.2 Site description for core X00/4 Top of track up to the Lake Eyles hut

The coring site is situated at the top of the track up to Lake Eyles hut (Fig. 3; see Fig. 1 for map location), just below the local tree line, at the bottom of a steep slope/cliff of the ledge the hut sits on. The site is situated on a run-out zone of the slope, and just within the upper limit of *Nothofagus menziesii* forest (slope does not have complete forest cover). It is a poorly drained depression on a fan that spreads off this slope. There is a river course 30 m away down slope in forest with abundant *Hoheria glabrata* with an understorey of *Polystichum vestitum*.

Forest canopy consists of *Nothofagus menziesii* 10–18 m high; 70% cover. Understorey: small-leaved coprosmas including *Coprosma pseudocuneata* 80%, *Pseudopanax colensoi* 2%, *Hebe* 1%. Ground cover: occasional *Astelia nervosa* and *Blechnum montanum*, *Polystichum vestitum*, and *Hymenophyllum* sp. abundant on logs. Clearing ground cover: *Sphagnum australe* (45%); *Hymenophyllum* sp. (20%), *Bulbinella* sp. (2%); *Blechnum penna-marina* (5%); *Chionochloa flavescens* (10%); *Uncinia* sp. (5%); *Gaultheria* sp. (5%);

Hypochaeris radicata (1%); Orchid sp. (1%); *Coprosma pseudocuneata* (1%); *Dracophyllum prostratum* (1%); *Euchiton* sp. (5%).

A 50-cm core was taken from the true right of track, in a small clearing 10 H 6 m in area. The slope was c. 8°C, the soil c. 66 cm deep, which bottomed out on gravel and wood. The core was sub-sampled for pollen contiguously at 1–3 cm, 3–6 cm, 6–9 cm (unconsolidated semi-decomposed *Sphagnum*), then every 1 cm below this.

X00/4 stratigraphy

0–10 cm *Sphagnum* moss, mostly live, decomposing layer 9–10 cm

10–26 cm yellow-brown *Sphagnum* peat moss, fibrous poorly humified

26–35 cm dark brown/black peat, more finely fibrous and humified than above

35–50 cm dark brown/black soil peat contains fine silts.

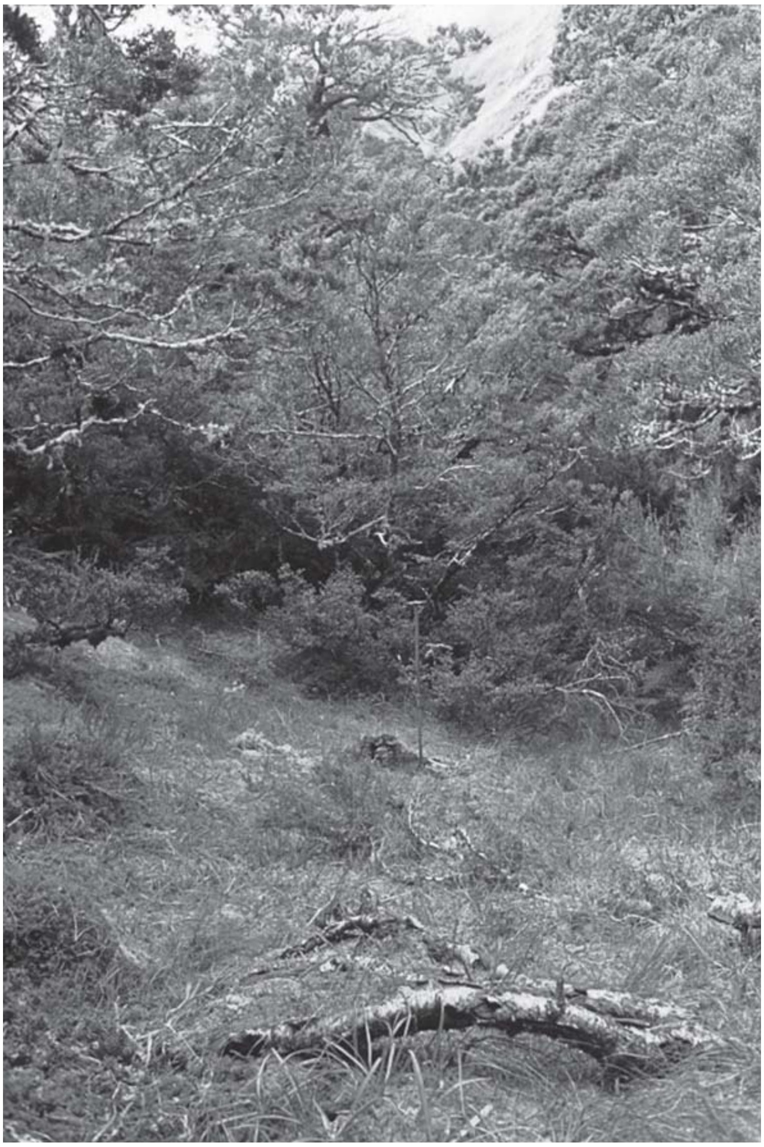

Figure 3. Coring site X00/4, Lake Eyles Track.

4.3 SURFACE SAMPLES

Fourteen surface moss samples were collected from the Chester Burn catchment from areas approximately 5 × 5 m in size, and the vegetation cover estimated, to assist with interpreting fossil pollen and spore representation (Table 2). Fresh fern spores were also collected from a number of fern species including *Hypolepis millefolium*, *Polystichum vestitum*, *Histiopteris incisa*, *Paesia scaberula*, to make up reference slides and assist with fossil identifications.

TABLE 2. SITE DETAILS AND ESTIMATED VEGETATION COVER FOR SURFACE MOSS SAMPLES.

SAMPLE	LOCATION	GRID REFERENCE NZMS 260 SHEET C42	ALTITUDE (m a.s.l.)	DOMINANT VEGETATION COVER
X00/7/SS1	Above Lake Eyles*Sphagnum cristatum* collected over 20 m around the edges of 2 small tarns (3–10 m × 4 m) which have formed on a little terrace in a block field	765 357	1300	Grassland, dominated by *Chionochloa crassiuscula*
X00/7/SS2	Above Lake Eyles *Sphagnum cristatum* moss in shrubland		1040	Subalpine shrubland dominated by *Dracophyllum uniflorum* and *Chionochloa flavescens*
X00/7/SS3	Eyles upper plateau by core site X00/2	769 359	880	Same as described for coring site X00/2
X00/7/SS4	On tarn rock knoll above Lake Eyles hut, moss taken next to core site X00/1	765 357	1030	Subalpine shrubland dominated by *Dracophyllum uniflorum*
X00/7/SS5	On blocky debris slope above Lake Eyles, at south-west end of lake, close to the western flank (very steep). *Usnea* collected from *Olearia*	764 356	1030	Subalpine scrub dominated by small leaved coprosmas, with *Polystichum vestitum* and *Hypolepis millefolium*
X00/7/SS6 [80 m north of SS5—for comparison of sampling materials]	Large rock (10 × 4 m) jutting out of scrub on lake edge. Moss collected from rock over 1 H 2 m.	765 356	1030	Dense subalpine scrub dominated by *Hoheria glabrata* and *Olearia* sp. with *Polystichum vestitum, Celmisia* and some *Hypolepis millefolium* in lower tiers.
X00/7/SS7	Tarn 30 m from hut (SE) on same plateau *Sphagnum cristatum* collected from around the rim of a tarn (5 × 5 m)	766 356	1030	Tussock shrubland dominated by *Chionochloa* spp.
X00/7/SS8	Below Eyles hut	766 355	990	See core X00/4 for vegetation
X00/7/SS9	Base of steep drop and just past confluence of main streams above Upper Plateau Bog. Moss from edge of clearing	768 358	900	Edge of clearing, 25 × 10 m, in tall *Nothofagus menziesii* forest including *Polystichum vestitum* and *Hypolepis millefolium* in understorey
X00/7/SS10	On second lower plateau below L. Eyles. Tree-fall clearing (50 × 20 m). Moss collected from branches of a fallen silver beech tree to avoid massive *Hymenophyllum* spore over-representation from the carpet-like covering of this fern at the site	773 359	815	Open canopy of *Nothofagus menziesii* with *Hymenophyllum* dominating ground cover with occasional *Polystichum vestitum* and *Uncinia* sp. in understorey
X00/7/SS11	Heart Shaped Lake—edge of wetland 15 m from forest edge, next to coring site X00/5	782 382	600	Wetland dominated by small-leaved coprosmas, *Carex* sp., and *Sphagnum cristatum*
X00/7/SS12	Upper Chester Burn forest, clearing near track towards Heart Shaped Lake	784 375	635	Tree-fall clearing in *Nothofagus menziesii* forest with understorey including *Polystichum vestitum, Hypolepis millefolium* and *Histiopteris incisa*
X00/7/SS13	On upper Chester Burn track, on steep slope	784 371	525	Under *Nothofagus menziesii* canopy
X00/7/SS14	Adjacent to Chester Burn Mouth hut	777 322	320	Under *Nothofagus menziesii* canopy

TABLE 3. DETAILS OF TAKAHĒ SIGN SAMPLES ANALYSED FOR POLLEN CONTENT.

SAMPLE	ALTITUDE	SITE DESCRIPTION (m a.s.l.)	GRID REFERENCE NZMS 260 SHEET C42
X00/17/1	1200	Grass shrubland above tree line, Lake Eyles	765 366
X00/17/2	1020	Above Lake Eyles Hut among tussock grasses	765 357
X00/17/3	885	Upper Plateau Bog Chester Burn, next to tussock grasses showing signs of takahē grazing	769 359
X00/17/4	800	Lower Plateau Bog, Chester Burn	772 360
X00/24/1	920	Mystery Burn	860 320
X00/24/2	640	McKenzie Burn	749 385
X00/24/3	940	Ettrick Burn	873 398

4.4 TAKAHĒ FAECAL SAMPLES

Takahē faecal deposits (sign) were seen at several of the coring sites, and in one instance on Upper Plateau Bog, Chester Burn, next to *Chionochloa* spp. and *Poa* spp. plants that had been grazed. To see if diet could be determined from sign, four relatively fresh takahē faecal samples were collected from these sites and analysed for their pollen content (Table 3). Jane Maxwell (DOC, Te Anau) also collected three fresh takahē sign (Table 3), one each from Mystery Burn, McKenzie Burn, and Ettrick Burn during the winter of 2000, and these were also pollen-analysed to compare with the summer samples collected from Chester Burn.

4.5 POLLEN ANALYSIS

All pollen samples 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 dry-land pollen sum of at least 300 grains was reached. Percentage calculations are based on dry-land pollen sum (which excludes fern spores as they tend to occur locally in very high concentrations and can distort the sum). The area of microscopic charcoal fragments (referred to here as micro-charcoal) was quantified in two classes (<50 μm and >50 μm) using the point count method of Clark (1982). The results are expressed as a charcoal index (hits per 11 points per field of view, calculated 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). Poaceae grains were split into two size classes, <40 μm and >40 μm, the smaller grains include *Poa* spp. and *Microlaena* spp., the larger grains those of *Chionochloa* spp. (M.S. McGlone & N.T. Moar, pers. comm.). Where possible, Cyperaceae grains were identified to one of 12 types recognised by Moar & Wilmshurst (2003), including *Carex, Uncinia* and *Eleocharis* types. *Celmisia* type includes *Celmisia* spp., but excludes *Raoulia* spp., *Olearia* spp., *Ozothamnus* and *Senecio* spp. *Raoulia* type includes *Raoulia* spp. and *Olearia* spp. *Nothofagus* subgenus *Fuscospora* (following the classification of Hill & Read 1991 and Hill & Jordan 1993) includes the pollen of

N. fusca, N. solandri, N. solandri var. *cliffortioides,* and *N. truncata*, which have indistinguishable pollen, and are referred to here as *Fuscospora.* Some pollen grains can only be identified to genus and therefore represent many species, most notably *Coprosma.* Monolete fern spores are smooth ground-fern spores that have lost their distinctive perine or have no exine markings, and therefore are not identifiable to species. The first evidence of Pinaceae (pine) pollen in the fossil profiles is used to provide chronological control, and to represent the later European period (post-1950s).

5. Results

5.1 SURFACE POLLEN

The surface pollen diagram (Fig. 4) shows that most samples are dominated by *Fuscospora* and *Nothofagus menziesii* pollen, with most other taxa recorded at less than 5% of the pollen sum.

5.2 SIGN OF THE TAKAHĒ

Four of the seven takahē sign collected had sufficient pollen to make a pollen count (Fig. 5). Three from the Chester Burn catchment were dominated by grass pollen, which made up 88–99.5% of the pollen sum (Fig. 6). Of these Poaceae grains, *Poa* type was more abundant than *Chionochloa* type pollen. In contrast, the Ettrick Burn sample (X00/24/3) was almost entirely dominated by spores from the ferns *Hypolepis millefolium* and *Polystichum vestitum,* with some *Uncinia* type and Poaceae pollen. One of the Chester Burn samples (X00/17/2) and the Mystery Burn sample (X00/24/1) contained no pollen. The McKenzie Burn sample (X00/24/2) contained very few pollen and spores, but did contain some *Hypolepis millefolium* and *Polystichum vestitum* and plant remains (fern tissue) similar to that found in the Ettrick Burn sample.

5.3 FOSSIL POLLEN RECORDS

Both pollen diagrams (Figs 7 and 8) have been split up into zones based on the major changes in pollen composition to aid their discussion, and are described below (from the bottom of the core up).

5.3.1 X00/2 Eyles Upper Plateau Bog forest margin

Zone 1 (45–20 cm)

Dominated by *Nothofagus menziesii* and *Fuscospora,* with Poaceae (mostly smaller *Poa/Microlaena* type), *Coprosma*, Cyperaceae (mostly *Uncinia* type), *Forstera* and monolete fern spores (mostly *Blechnum* spp.). Trace amounts of other fern spores.

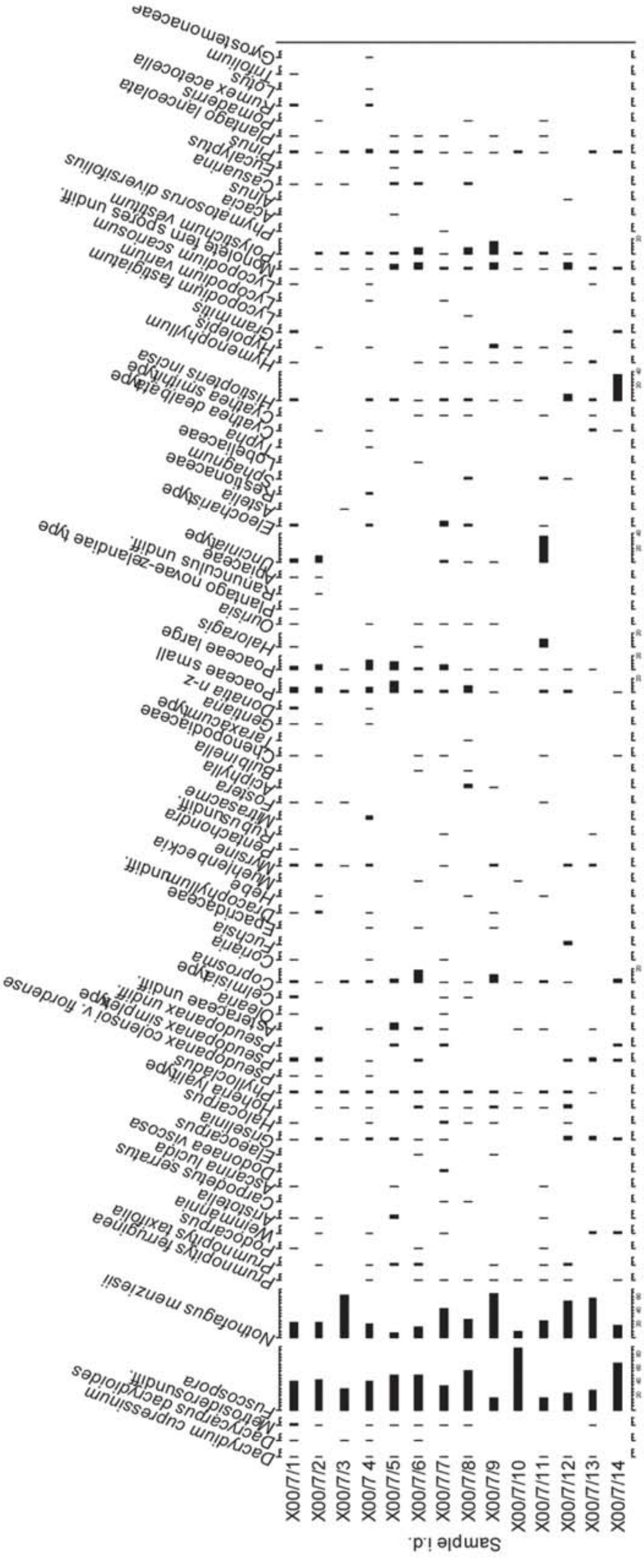

Figure 4. Percentage pollen diagram for surface samples.

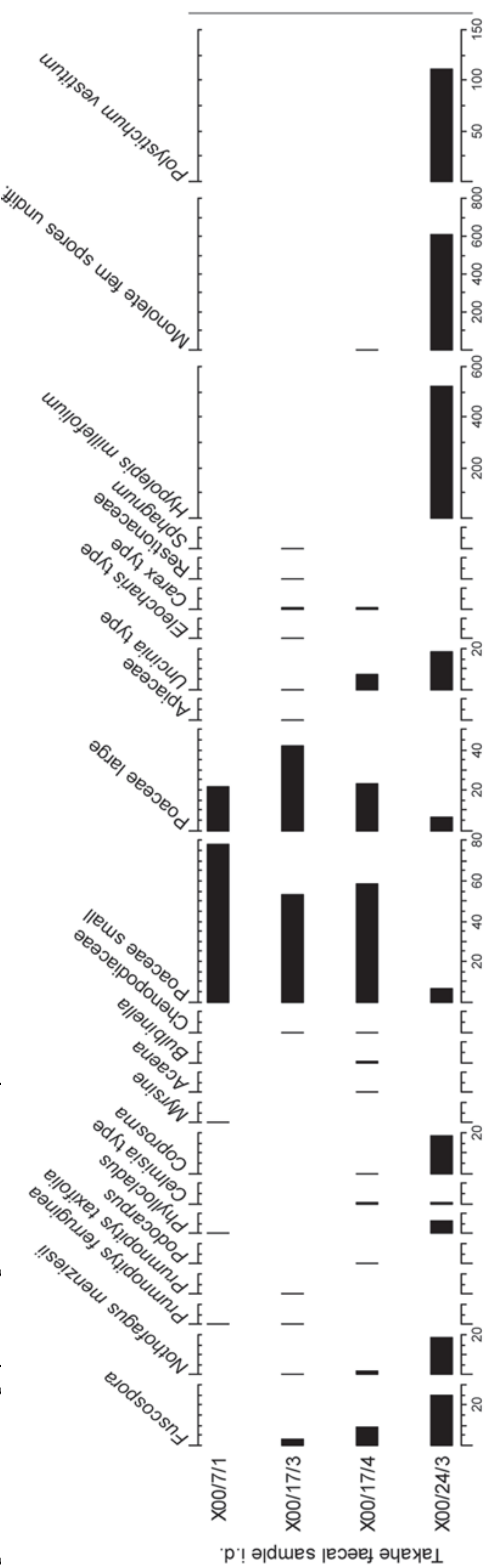

Figure 5. Percentage pollen diagram for takahē faecal samples.

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