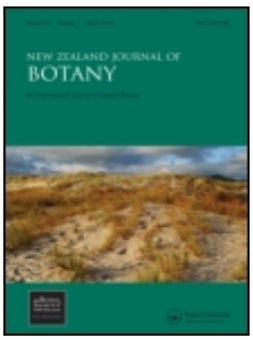

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R. G. Bagnall & C. C. Ogle

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The changing vegetation structure and composition of a lowland mire at Plimmerton, North Island, New Zealand[1]

R. G. BAGNALL[2]

Department of University Extension, Victoria University of Wellington, Private Bag, Wellington, New Zealand

C. C. OGLE[3]

8 Donlin Road, Pukerua Bay, New Zealand

Abstract The composition, structure, and biological status of the vegetation in a lowland topogenous mire were studied, with particular attention to the elucidation of current successional patterns. Twenty-four vegetation types were described and mapped. Sedgeland and tussockland covers much of the mire, *Carex lessoniana*, *Carex secta*, and *Phormium tenax* being the major species. Only 50% of the 165 vascular species recorded from the mire are indigenous, although most of the exotic species are of only minor importance in the vegetation. Succession was found to be advancing in the earlier seral stages towards a *Phormium* tussockland, the more advanced stands of which showed seral reversal under the influence of a rising water table, preventing the development of mire shrubland and forestland.

Keywords plant succession; vegetation types; mire; Plimmerton, New Zealand; peat; adventive plants; indigenous plants; population age-structure; vegetation map; point-sampling

INTRODUCTION

The Taupo mire is one of only a few lowland topogenous mires in the Wellington district that have retained a largely indigenous vegetation cover. Although an earlier study of the mire and its vegetation was made by Moar (1949, 1953), subsequent changes in both the mire itself and the Taupo valley have indicated the need for further research.

Recent attempts to obtain legal protection for the mire vegetation have raised many doubts as to the adequacy of such protection for ensuring its survival. In particular, it was suggested that exotic weeds such as blackberry *(Rubus fruticosus)* and pussy willow *(Salix atrocinerea)* were rapidly displacing the indigenous vegetation, that ecological succession would shortly lead to the current mosaic of vegetation types being replaced by a rather uniform mire forest, and that farming followed by urban development of the lower valley and surrounding hill slopes would destroy the mire.

To address these questions, the mire was studied during 1977 and 1978. The aim was to develop sufficient understanding of the structure, composition, and ecological status of the mire vegetation to permit sound recommendations to be made on its future management. This paper reports the findings.

STUDY AREA

The Taupo mire lies north of Wellington, between Pukerua Bay and Plimmerton. It occupies the lower part of the Taupo Valley and its branches, extending from grid reference (NZMS 1, Hutt, N 160) 475422 in the south to 498426 in the north.

Although the mire is considered to have formed in a lagoon which was previously an inlet of Porirua Harbour (Adkin 1921), it is now a freshwater topogenous mire (Moar 1949) fed by the Taupo Stream and its tributaries. The surface of the silty peat, which forms the upper soils of the mire, now rises from *c.* 2 m above mean sea level, behind the beach

[1]This constitutes Department of Internal Affairs Wildlife Service Publication No. 252.

[2]Present address: Department of Continuing Education, University of New England, Armidale, N.S.W. 2351, Australia.

[3]Present address: Wildlife Service, Department of Internal Affairs, Private Bag, Wellington, New Zealand.

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at Taupo Bay (Moar 1953), to *c.* 23 m at the intersection of Airlie Road and State Highway 1 (Hall 1946). The water table is generally at about the surface of the peat, occurring locally above or below.

The catchment substratum is greywacke argillite and sandstone, which is overlain across much of the area by deposits of glacial loess and wind-deposited sand (Stevens 1974). The soils that are formed on these deposits have a moderate erosion rating (Heine 1975), although the loess is prone to rapid scouring in run-off if the soil surface is broken.

Most of the catchment has been under pasture since the late nineteenth century, although marginal infilling of the mire has occurred with the development of the Main Trunk railway, State Highway 1, and Whenua Tapu Cemetery, and the mire below Winstone Clay Products Ltd factory is being filled for industrial development. There is also a small area of recent fill at the northern end of the mire (Fig. 1).

The mire itself has been grazed, especially in the lower section, and drainage channels have been cut along its length (Fig. 7). In recent years, however, little effort has been made to manage the mire for grazing, and a progressive rise in the water table has forced the farmers to remove all stock (O. Benge, Plimmerton Farm; pers. comm.). The extensive flaxlands in the mire were cut for fibre in 1947 (Moar 1953) and probably on occasions since then, but not within the 15 years before completion of this study.

METHODS*

Vegetation types were defined and mapped from field observation and aerial photographs (Department of Lands and Survey, 7 November 1971, 3496: J/6 to J/10). Representative areas of each type were used for their description and naming, after the procedure of Atkinson (1962), except that vegetation in all strata (not only the canopy plants) was considered in determining the name. Because of their ecological importance in the mire, and their apparent vigour, the areas of bracken (*Pteridium esculentum*) and blackberry were mapped to produce a comparative base for future studies. Their outer canopy cover and that of all erect woody trees and shrubs in each area were estimated.

Throughout the survey, an annotated list of all vascular plant species observed from the mire proper and the adjacent hill slopes was compiled.

Comparative data to determine historical changes in vegetation structure and species composition were obtained from a survey in 1947–49 (Moar 1949, 1953), and from aerial photographs taken in 1942 (Department of Lands and Survey No. 321/9 and 321/10, 17.3.1942) and 1963 (No. 1530, B/3 to B/6, 14.5.1963).

To determine the stability of the blackberry clump margins, 2-m-wide transects were laid through five margins of three different clumps (Fig. 5), and the relative densities of live and dead stems were assessed along the transects.

The growth and dispersal of pussy willow plants in the mire were studied using systematic samples, from which their age, height, and degree of layering were recorded.

Particular attention was paid to the *Phormium* tussockland vegetation type because of its extensive area in the mire, and the presence of shrub and tree species within it. It was assumed that if this vegetation type were developing into forestland, the trend should be evident in the age or size distribution of its component tree and shrub species. Also, because the peaty-alluvial soils in mires of this type usually develop more rapidly toward the head of the mire, such seral change would be expected to advance with progression up the mire. Based on these assumptions, either 50 or 60 random samples were selected from each of 4 sample areas in this vegetation (Fig. 1). Each sample was centred on a point-sampling instrument (Bagnall 1978), used to record the specific identity and height above the soil surface of each live vegetation contact along a vertical line of sight. Centred on this pole were two plots: one a vertical cylinder of 50 cm radius, the other a horizontal ground-level projection of 2 m radius. These were used to determine (1) the outer cover-percent and mean canopy height above ground of each species (based on the uppermost point-intercept datum from each line of sight); (2) the vegetation volume of each species (based on the total point-intercept data); (3) the frequency percent occurrence of each species (based on the presence of each species in the 50-cm-radius plots); (4) the live density, by vertical-height class (from 10 cm height), of each erect woody shrub and tree species (based on the 2-m-radius plots); and (5) the mean water depth (based on the maximum depth within each 50-cm-radius plot).

RESULTS

Vegetation mapping

Twenty-four distinct vegetation types were recognised (see key to Fig. 1; Appendix 1). Although the boundaries between the types (Fig. 1) were not often sharp, there were distinct structural and compositional differences between the types. In only one type (s6 — *Carex* sedgeland) was the homogeneity so low that alternative, descriptive type names were required. In this type, the variation was too complex to map accurately, so that a single type was accepted but with a range of descriptions.

*Further details of the procedures and results of this study are contained in a full report, file no. 37/4/22, available on request from the Wildlife Service.

Most of the mire is under either sedgeland or tussockland (Figs 2, and 3). In the sedgelands, *Carex lessoniana* predominates, with high cover values for *Baumea rubiginosa* in many places. In the tussockland, flax (*Phormium tenax*) mostly is dominant, with niggerhead (*Carex secta*) and toetoe (*Cortaderia toetoe*) as common associated species. Raupo (*Typha orientalis*) is co-dominant in only a few small areas along drainage channels (s5 — *Typha/Carex* reed sedgeland), but occurs as an associated species in many other vegetation types. The well developed *Phormium* tussockland has a conspicuous growth of associated shrubs — mostly karamu (*Coprosma robusta*) and koromiko (*Hebe stricta*) — but shrublands generally are not prominent. The main areas of shrubland are dominated by pohuehue (*Muehlenbeckia complexa*) and pussy willow (sh2 — *Muehlenbeckia/Poa* grass shrubland, and sh3 — *(Salix)/Muehlenbeckia–Poa* grass shrubland), and there is one small area of manuka shrubland (sh4 — *Leptospermum/Coprosma"Pteridium* fern shrubland). The sh2 and sh3 vegetation types are the most notable in this mire, being dominated by a dense, deep growth of *Poa anceps* and pohuehue — unusual vegetation to be found on a peat mire. The only type of scrub present is that dominated by blackberry (sh1 — *Rubus* scrub).

The treeland at the northern end of the mire (tr — *Salix/Mentha* herb treeland) is not a naturally occurring type, and owes its presence to the earlier planting of crack willow (*Salix fragilis*), with some peripheral pussy willow and Lombardy poplar (*Populus nigra*).

On the drier sites, fernlands, dominated by bracken (types f1–f3), are well established. The grasslands (types g1–g3) — occurring mostly in the southern part of the mire — are dominated overwhelmingly by exotic grasses, with fennel (*Foeniculum vulgare*) having established on one of the drier sites (type g3). Herbfields (h1–h4), also occurring predominantly in the south, show a diversity of component species, but with one notably aggressive invader — beggars' ticks (*Bidens frondosa*). Other conspicuous herbfield species are creeping buttercup (*Ranunculus repens*), monkey musk (*Mimulus guttatus*), and *Polygonum* sp.

Bracken areas (Fig. 4) are frequently associated with sparse, emergent shrub growth, and occasionally with blackberry. Blackberry, however, occurs more commonly in dense, largely monospecific stands.

Species recorded

Of the 165 species (and 2 hybrids) that were recorded from the mire proper (Appendix 2), 83 (50%) are indigenous. Of these latter, the following may be noted as being common in this mire but not so elsewhere in the Wellington district: *Coprosma tenuicaulis*, *Epilobium pallidiflorum*, *Galium trilobum*, and *Urtica linearifolia*. Also of interest, but rare in the mire, are *Carex maorica* and *Ranunculus macropus*.

Of the 171 species (51% of the total, and including 5 hybrids) that were recorded only on the hill slopes adjacent to the mire, 92 (54%, including 1 hybrid) are roadside or railway weed species, most of which — 82 (89%) — are exotic.

Of the total 338 species (including 7 hybrids) recorded, 183 (54%, including 3 indigenous New Zealand species) are regarded as exotic to the area. Some of these are judged to have been deliberately planted, particularly: golden wattle (*Acacia floribunda*), macrocarpa (*Cupressus macrocarpa*), tree lucerne (*Chamaecytisus palmensis*), Lombardy poplar, *Pseudopanax lessonii*, radiata pine (*Pinus radiata*), pussy willow, crack willow, and kowhai (*Sophora* sp.). Other exotics are probably garden escapes from material dumped along the roadside, particularly: hydrangea (*Hydrangea macrophylla*), the mints (*Mentha* spp.), parsley (*Petroselinum crispum*), garden nasturtium (*Tropaeolum majus*), three-cornered garlic (*Allium triquetrum*), canna lily (*Canna indica*), montbretia (*Crocosmia* × *crocosmiiflora*), purple spiderwort (*Tradescantia virginiana*), *Tritonia* sp., and arum lily (*Zantedeschia aethiopica*). Apple (*Malus domestica*), peach (*Prunus persica*), and plum (*Prunus domestica*) have evidently established from human-dispersed seed beside the railway, but most of the remaining exotics would be animal or wind dispersed.

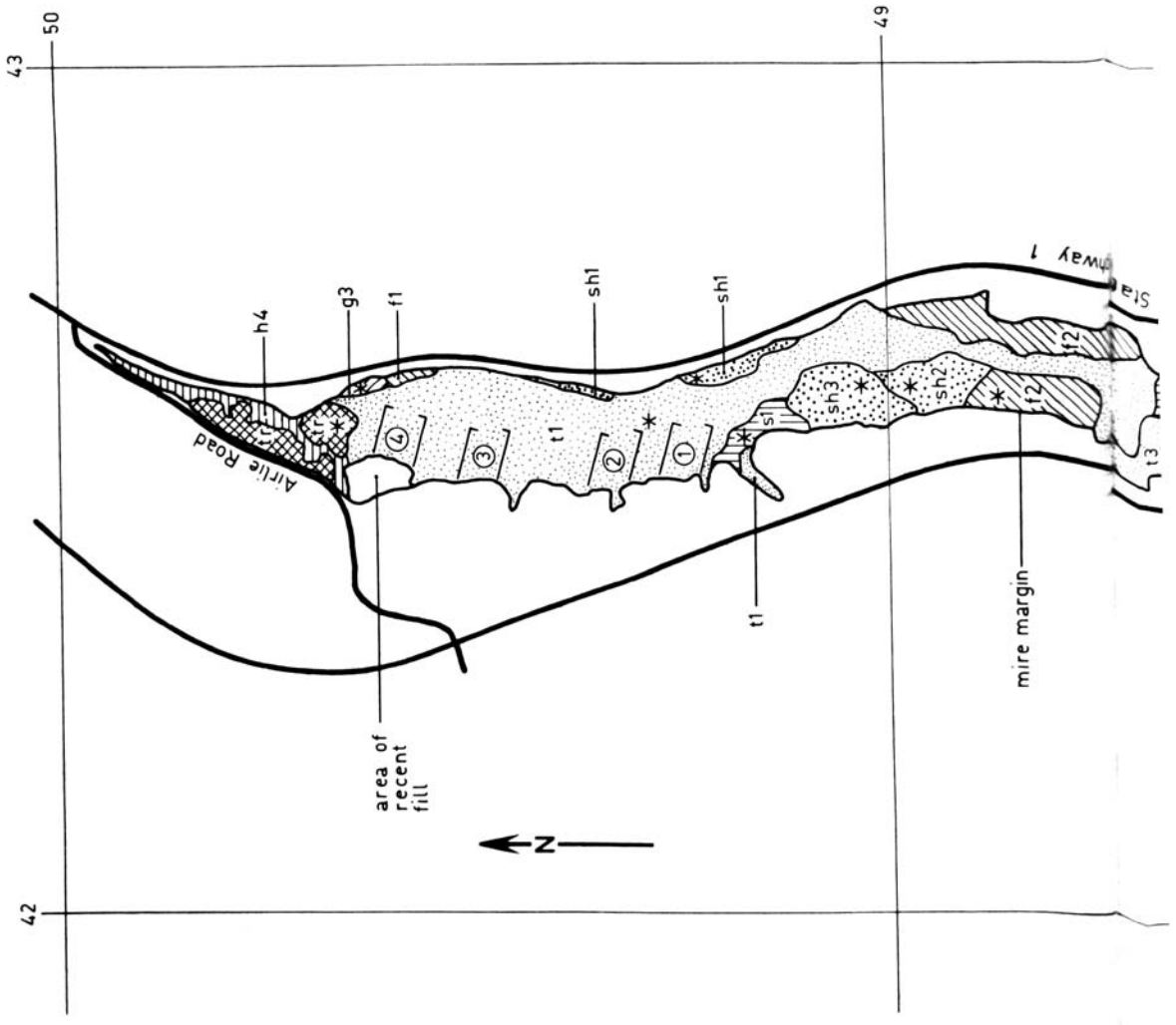
Of the species recorded by Moar (1949, 1953), the following appear to have become extinct in the mire: *Drosera binata*, *Euphrasia cuneata*, jointed rush (*Leptocarpus similis*), *Lagenifera cuneata*, *Lobelia anceps*, *Potamogeton cheesemanii*, and *Schoenus nitens* (also noted as *S. concinnus*). The extinctions of these species are associated with the loss of the two vegetation types in which they occurred — *Leptocarpus* rushland, and a mixed reed herbfield.

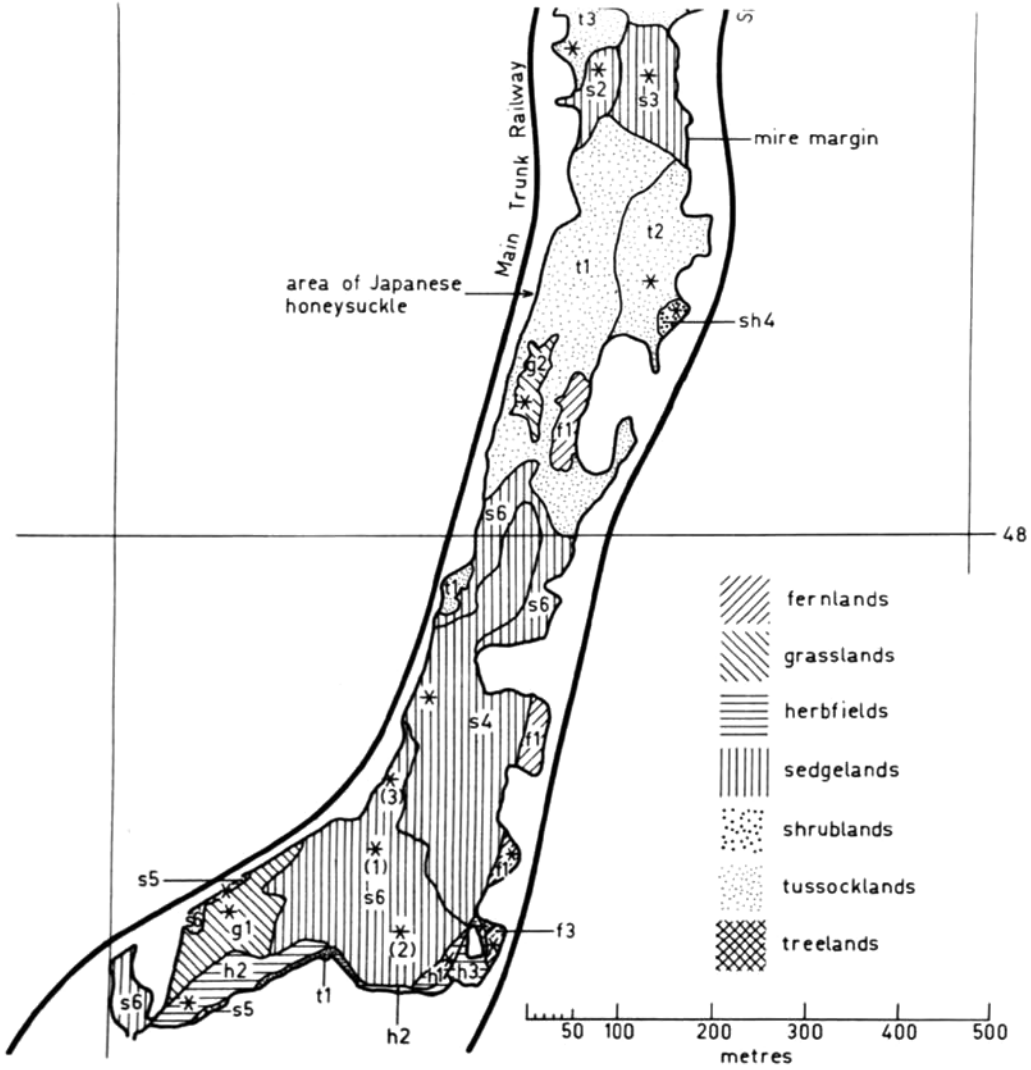
Historical vegetation changes

The vegetation map shown in Fig. 5 is based on Moar's 1947–49 survey of the mire. Because of lack of definitive textural features among the vegetation types in the 1942 and 1963 aerial photographs it was not possible to use these photographs to draft accurate historical maps.

Moar (1949) discussed the following vegetation types (with descriptive titles given by us; the symbols refer to the areas in Fig. 5):

1. *Phormium/Carex* tussockland (t4)
   Dominated by a tall, dense growth of flax, through which grew a few "spindly" shrubs of





Key to vegetation types

f1	*Pteridium* fernland
f2	*Phormium/Pteridium* tussock fernland
f3	*Pteridium/Dactylis* grass fernland
g1	*Festuca–Holcus* grassland
g2	*Carex/Holcus* tussock grassland
g3	*(Foeniculum)/Dactylis–Festuca* herb grassland
h1	*Scirpus–Mimulus–Polygonum* sedge herbfield
h2	*(Bidens/Festuca–Ranunculus)* grass herbfield
h3	*Bidens* herbfield
h4	mixed sedge herbfield
s1	*(Phormium–Typha)/Baumea–Carex* tussock sedgeland
s2	*(Phormium–Cortaderia)/Baumea* tussock sedgeland
s3	*Phormium/Carex–Calystegia* tussock sedgeland
s4	*Phormium/Carex* tussock sedgeland
s5	*Typha/Carex* reed sedgeland
s6(1)	*Carex* sedgeland
s6(2)	*Carex/Ranunculus* herb sedgeland
s6(3)	*Carex* herb sedgeland
sh1	*Rubus* scrub
sh2	*Muehlenbeckia/Poa* grass shrubland
sh3	*(Salix)/Muehlenbeckia–Poa* grass shrubland
sh4	*Leptospermum/Coprosma–Pteridium* fern shrubland
t1	*Phormium* tussockland
t2	*Phormium–Cortaderia/Carex* sedge tussockland
t3	*(Phormium)/Carex–Baumea* sedge tussockland
tr	*Salix/Mentha* herb treeland

Fig. 1 Vegetation map of the Taupo mire. Asterisks mark the positions of each type-area used in the vegetation descriptions. Areas numbered 1–4 show the positions of *Phormium* tussockland samples. Boundaries between most vegetation types were indistinct, and should be regarded as approximate only.

Fig. 2 Lower study area, looking SE towards Winstone's factory (upper right): *Carex* sedgeland (s6) in foreground; *Phormium/Carex* tussock sedgeland (s4) above.

Fig. 3 Upper study area, looking E: *Phormium* tussockland (t1), with recent fill in foreground.

karamu and koromiko. Niggerhead formed a dense understorey.

2. *Cortaderia/Carex* tussockland (t5)
Dominated by toetoe and niggerhead, with associated raupo and stunted flax.
3. *Typha–Phormium* tussock reedland (re)
Dominated by raupo, with flax, and some toetoe and *Carex virgata*.
4. *Pteridium* fernland (f1)
Dominated by bracken.
5. *Leptocarpus* rushland (ru)
An area "of several square yards" dominated by jointed rush, with a diversity of associated species.
6. Mixed sedge tussockland (t6)
An induced mosaic of flax, toetoe, niggerhead, and raupo; with *Carex lessoniana* or *C. geminata* (= *C. ternaria* of Moar) dominant in the south (opposite Winstone's factory).
7. Mixed reed herbfield (h5)
This association formed a narrow strip on the western margin of the mire, extending along almost its entire length. It was described as a low-growing vegetation mat, with the following characteristic species: *Centella uniflora*, *Schoenus concinnus*, *Eleocharis gracilis*, *Gnaphalium collinum*, *Lagenifera cuneata*, and *Hydrocotyle moschata*.

When Moar's (1949) records are compared with those of the present survey, it is notable just how little the vegetation has changed in the intervening 30 years. However, the following changes should be noted:

1. The *Phormium/Carex* tussockland area now has successionally advanced to a *Phormium* tussockland, with a decrease in the importance of niggerhead and lower-growing species (e.g., *Eleocharis acuta* probably no longer occurs in this area, and *Epilobium pallidiflorum* is rarely found). Marginal areas of stunted flax noted by Moar (1949) have increased in vigour, and are no longer distinguishable from those more centrally placed. However, there has been no noticeable development of the shrub species.

2. The *Cortaderia/Carex* tussockland and the *Typha–Phormium* tussock reedland areas now include much less raupo and niggerhead. Parts of these areas have developed into *Phormium* tussockland, and the remainder into a variety of tussock sedgelands, sedge tussocklands, tussock grassland, and fernland. Toetoe remains an important component, and *Carex lessoniana* has increased greatly in importance. Also, shrub growth has become a feature in part of the area (t2 — *Phormium–Cortaderia/Carex* sedge tussockland).

3. *Pteridium* fernland has receded in some areas (giving way particularly to flax and *Carex lessoniana*), but has advanced or developed in others. One area of bracken has developed into the pocket of manuka (*Leptospermum scoparium*) shrubland (s4 — *Leptospermum/Coprosma–Pteridium* fern shrubland).

4. The *Leptocarpus* rushland, as the last remaining remnant of saline vegetation, is no longer present — the area being covered by a sedge herbfield and *Carex* sedgeland, with very swampy soils, not the summer-dry bog described by Moar (1949).

5. The mixed sedge tussockland now includes grassland areas which were not mentioned by Moar (1949, 1953).

6. The mixed reed herbfield is not now evident. This association was evidently like the mixed herbfields recorded in mires at Cape Turakirae (Bagnall 1975), which owe their structure and composition to continued grazing by stock. Stock removal from the Taupo mire, combined with earthworks along the margin, thus were probably influential in the loss of this vegetation type.

7. Blackberry and pussy willow areas have developed since Moar's (1949, 1953) surveys.

Exotic weeds

The extensive margin of the mire (relative to its area), and its proximity to major transport routes, make the mire vegetation especially vulnerable to invasion by weeds.

The following species were recorded, but found not to be a threat to the mire vegetation, for the primary reasons as indicated: (1) gorse (*Ulex europaeus*) and broom (*Cytisus scoparius*), open ground being necessary for their establishment, and the mire soil being too waterlogged; (2) fennel, the mire soils being too waterlogged; and (3) Lombardy poplar and crack willow, there being no female plants of these species.

In addition to the blackberry and pussy willow (discussed below), the following species were recorded and judged to be a threat to the mire vegetation in localised areas: (1) Japanese honeysuckle (*Lonicera japonica*), which is established in one area of *Phormium* tussockland (Fig. 1), from where it is spreading and smothering associated species in the tussockland; (2) *Glyceria maxima*, which forms several patches in the mire, especially in the *Phormium* tussockland, where it is spreading and smothering all but the flax clumps; and (3) beggars' ticks, which is well established in the south of the area (types h2 and h3), where it is aggressively colonising areas with a high water-table and low-statured vegetation cover.

Blackberry is present in clumps scattered throughout the mire (Fig. 4), especially along the

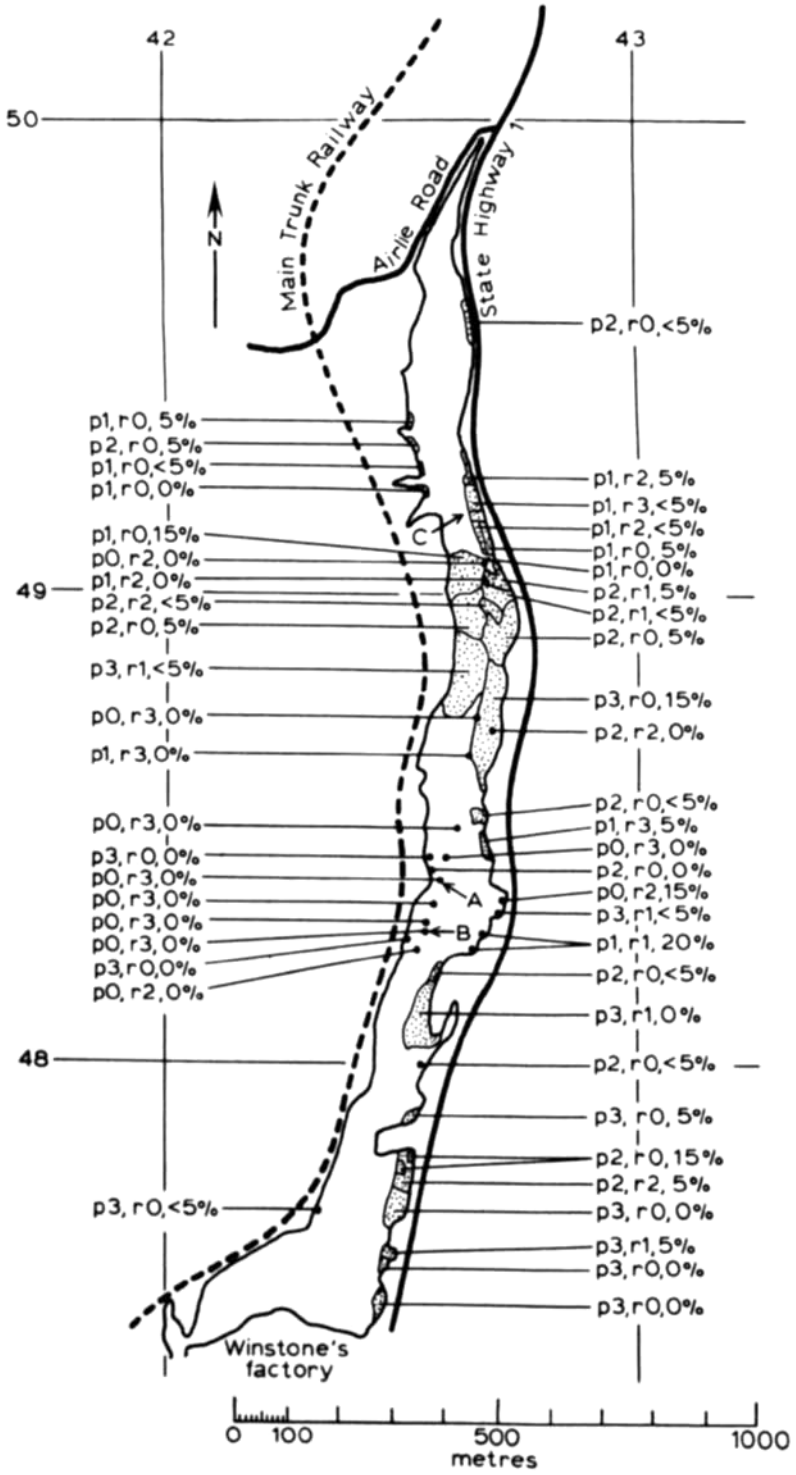


Fig. 4 Approximate distribution of bracken and blackberry in the Taupo mire. Areas too small to map are shown by dots; other areas are stippled. Outer cover values for bracken (p) and blackberry (r) are given on the scale: 0 = no cover, 1 = <30%, 2 = 31–70%, 3 = >70%. The percentage figure given for each area is the estimated outer cover of all erect woody trees and shrubs. A, B, and C indicate the location of blackberry sample lines.

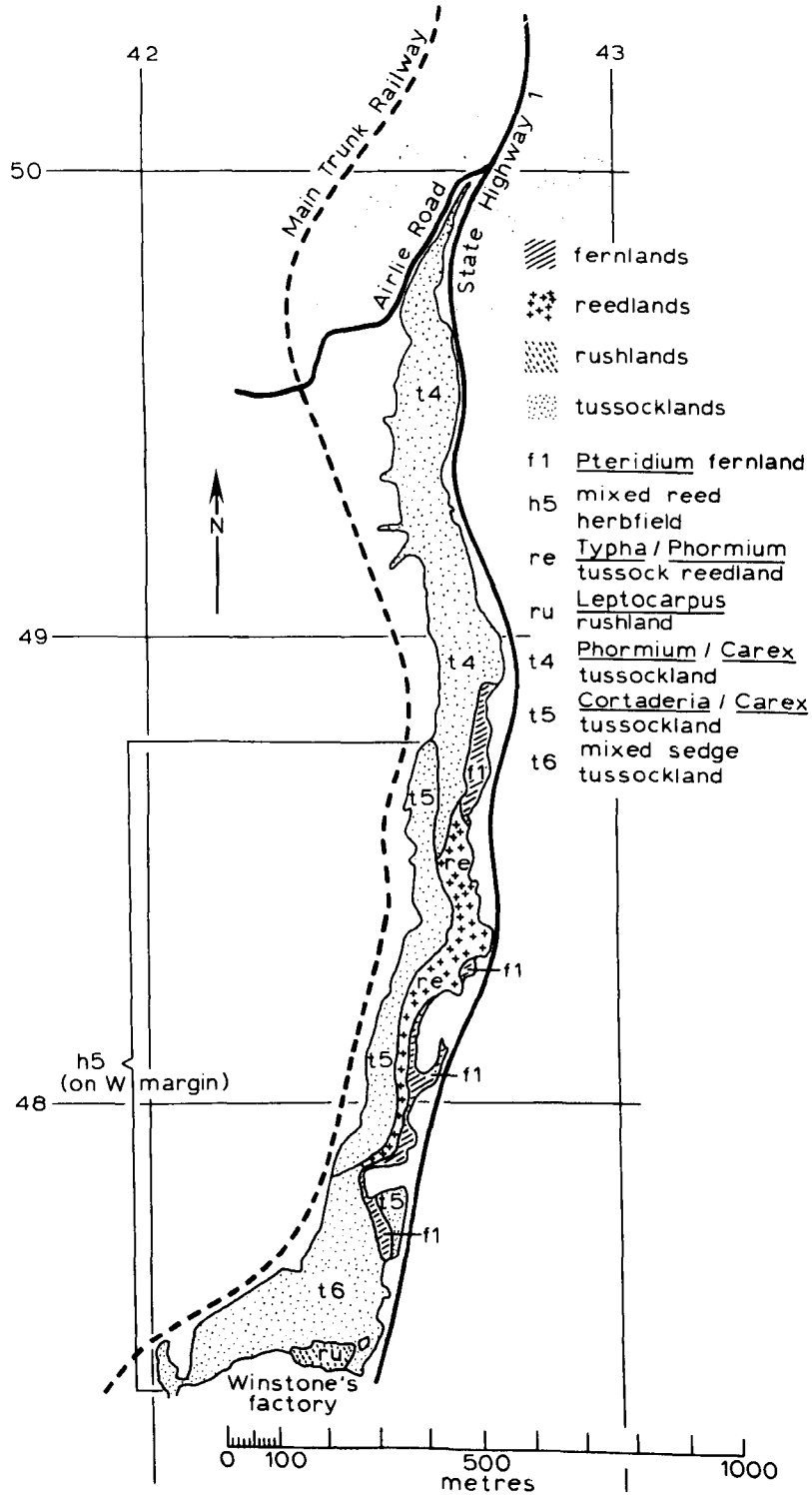


Fig. 5 Vegetation map of Taupo mire based on descriptive material provided by Moar (1949). Boundaries are approximate only.

Fig. 6 Pussy willow in *Carex* sedgeland (s6).

drainage channels. On open ground in the latter situations it was still spreading stoloniferously. However, the study clump margins that abut against established vegetation showed them to be static, since the number of live and dead stems per plant did not increase appreciably towards the periphery of the clumps.

Pussy willow (Fig. 6) also has dispersed widely throughout the mire (Fig. 7). Both male and female plants are present, and it shows a wide range of plant sizes — suggesting continued establishment. The largest specimens are on the southern edge of the crack willow stand, probably having been planted at the same time as that species (dated at late 1940s).

Data from 55 pussy willow plants (plus associated layered individuals) revealed a mature population, mostly in the 11–15 year age-range, but with some plants up to 31-years-old and as young as 4 years (Fig. 7). It is evident from the distribution of plant ages along the mire that this willow spread rapidly from north to south after its initial establishment at the head of the mire, seedling establishment reaching a peak between the mid 1950s and mid 1960s. Establishment from seed then rapidly declined to its present low level. Although layering was found to occur more or less uniformly over time, it does not lead to a marked spread of the willow, since the layering offspring are generally under the parent canopy, and the rate of layering is not high (e.g., only 33% of primary plants over 20-years-old had one or more layered offspring).

Phormium tussockland

Data from the *Phormium* tussockland samples show that in this vegetation type there is early successional advance with progression up the mire, but that this has ceased and begun a reversal towards the head of the mire.

Flax and niggerhead as the two dominant species, reflect this pattern, with niggerhead showing a progressive decline in canopy cover, and flax an initial increase which reverses in the terminal stands (Table 1). The same pattern is evident in the vegetation volume of these species (Table 1). The frequency of niggerhead plants (Table 2) also shows an initial decline, but this is followed by a marked regeneration in area 4 — as is supported by the large variance in its canopy height in that area (Table 1). The frequency of flax plants, however, does not vary greatly. It is therefore suggested that the changes in foliage cover and volume of flax are not associated with any marked changes in the number of plants; the recovery of the niggerhead population at the end of the sequence is not yet reflected in an increased contribution to the canopy cover or foliar density.

There is a general but not uniform fall in the contribution from occasional species across the sequence: from 21 to 8% in frequency, 28–14% in vegetation volume, and 13–8% in canopy cover. Although the differences are not statistically significant, there is also a suggested fall in total species frequency — from 4.8 species per plot in area 1, to 3.6 in area 4. Karamu gives consistently high frequencies (62–72%), although koromiko is increasing (from 16 to 54%), but there is insufficient data for canopy cover and vegetation volume to confirm this. Early seral species also show a decline in frequency, for example, *Baumea rubiginosa* and *Glyceria maxima* are found only in the first one or two areas, and toetoe and pohuehue diminish in frequency.

Aside from the variance of niggerhead already noted, the canopy height statistics (Table 1) do not show any trends, for either individual species or overall height. Nor is there any progressive diminution in water depth across the sequence, the water table being at or above the soil surface in each area.

The size distributions of trees and shrubs (Table 3) — whether viewed across the samples as a seral sequence, or examined within each area — show a pattern of stability leading to successional reversal.

Table 1 Canopy cover, canopy height, and vegetation volume in 4 sample areas within the *Phormium* tussockland. Only species contributing at least 5% to the cover or 10% to the volume in 1 or more areas are listed. Errors are to 1 standard deviation.

	Cover (%)				Canopy height (cm)				Volume (%)			
	1	2	3	4	1	2	3	4	1	2	3	4
Blechnum minus	2±2	4±3	6±3	—	120 –	49±67	52±22	—	5	14	14	2
Carex lessoniana	3±3	2±2	—	8±4	230±28	100 –	–	93±63	15	16	—	14
Carex secta	36±7	18±6	8±4	8±4	117±34	133±19	152±45	135±101	305	106	94	82
Coprosma robusta	5±3	14±5	8±4	12±5	141±55	172±49	188±62	187±41	12	24	14	26
Glyceria maxima	2±2	—	—	—	—	—	—	—	10	—	—	—
Phormium tenax	31±6	36±7	60±7	52±7	188±54	196±36	206±68	202±73	55	58	116	112
Poa anceps	2±2	3±3	—	—	—	—	—	—	5	14	—	—
Canopy gap	6±3	16±5	16±5	12±5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Other species	13±5	7±4	2±2	8±4	160±35	130±52	140 –	144±45	28	30	8	14
Total	100	100	100	100	n.a.	n.a.	n.a.	n.a.	435	262	246	250
Mean (all species)	n.a.	n.a.	n.a.	n.a.	141±73	139±75	158±99	157±95	n.a.	n.a.	n.a.	n.a.

Table 2 Frequency percent occurrence of vascular species in 4 sample areas within the *Phormium* tussockland. Only species showing a frequency of at least 5% in 1 or more areas are listed.

	Frequency % occurrence			
	1	2	3	4
Baumea rubiginosa	7	16	—	—
Blechnum minus	42	46	56	52
Carex lessoniana	18	6	—	18
Carex secta	78	72	60	122
Coprosma robusta	65	62	72	66
Coriaria arborea	7	16	2	—
Cortaderia toetoe	10	4	4	2
Fuchsia excorticata	2	—	6	2
Glyceria maxima	10	—	—	—
Hebe stricta	17	16	28	54
Hypolepis sp.	7	6	8	6
Melicytus ramiflorus	3	2	6	2
Muehlenbeckia spp.	44	2	4	12
Phormium tenax	83	82	98	94
Pneumatopteris pennigera	5	—	—	—
Poa anceps	23	54	4	—
Pteridium esculentum	5	4	—	—
Solanum dulcamara	2	12	—	—
Typha orientalis	27	46	32	6
Other species	21	22	16	8
Total	476	468	396	444

The dominant shrubs (karamu and koromiko) have an overmature population structure in each area. Koromiko also shows a positive association between successional advance and senility of the population. Thus, larger populations of taller plants are found in areas 3 and 4 than in areas 1 and 2. However, mahoe (*Melicytus ramiflorus*), because of its size when mature, could in future show an increase in canopy cover and vegetation volume. Of the less frequently occurring species, tutu (*Coriaria arborea*) is mature to overmature in all areas, and is not being replaced, and hangehange (*Geniostoma rupestre* var.) and broom are stable to declining.

DISCUSSION

When the changes that have occurred since Moar's (1949) study in the late 1940s, are considered in conjuction with the results of the *Phormium* tussockland study, the general pattern of change that emerges is one of limited seral advance in the earlier successional stages, with stability leading to decline in the later stages. This seral reversal is evidently caused by a rising water table.

The dense vegetation cover of the mire (in the continued absence of grazing by stock) will prevent the further spread of pussy willow, although there will be a limited increase in cover from layering and the continued growth of existing plants.

With a rising water table, the extensive areas of bracken will recede, rather than increase, in cover (Cockayne 1967), as will the areas of grassland. Similarly, broom and gorse will diminish in importance, both as a consequence of the rising water table and the density of the vegetation cover. Blackberry appears to be stable, and should not show substantial changes in cover in the absence of grazing. In the medium-term, beggars' ticks will increase its cover in the lower area, with the continued rising of the water table. However, flax should grow through to replace this species eventually. Japanese honeysuckle also seems likely to continue its advance, and the future of *Glyceria maxima* remains uncertain and should be examined further.

In the event of a resumption in succession toward mire shrubland and forest, there are available

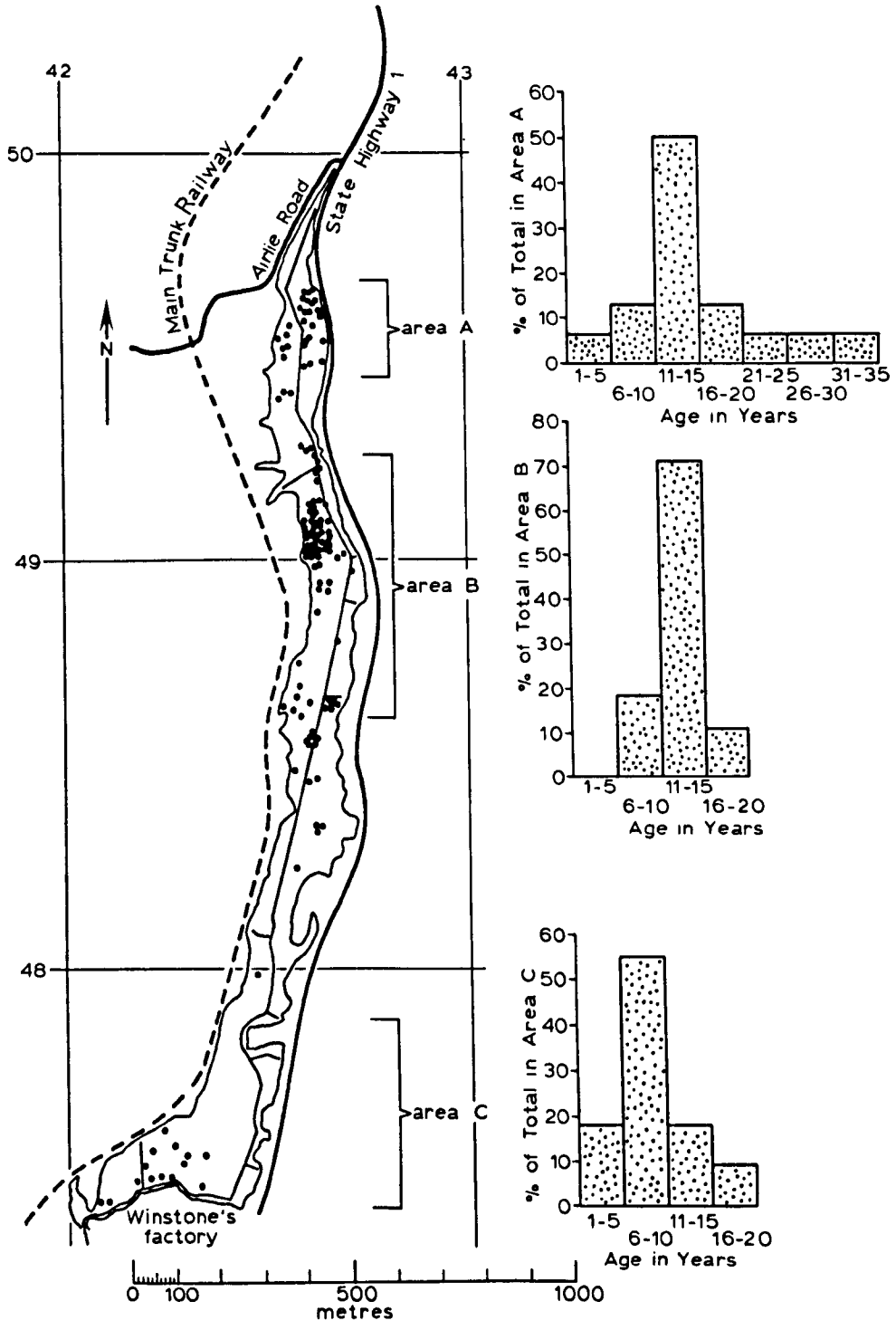


Fig. 7 Distribution of pussy willow in the Taupo mire. Dots indicate approximate position of pussy willow clumps. Lines within the mire represent drainage channels. Histograms show age distribution of primary pussy willow specimens sampled in each of the areas A, B, and C.

Table 3 Distribution, by height class, of woody erect tree and shrub species, in 4 sample areas within the *Phormium* tussockland. Only species showing a density of at least 400/ha in 1 or more areas are listed.

	Area no.	Number/ha by height class (cm)							
		10–50	51–100	101–150	151–200	201–250	251–300	301–350	>350
Coprosma robusta	1	491	411	650	928	1154	544	93	—
	2	477	455	557	541	700	525	207	80
	3	2036	255	302	540	700	350	239	111
	4	1114	207	239	302	589	557	238	80
	$\bar{x}$	1029	332	437	578	786	494	194	68
Hebe stricta	1	106	93	252	239	106	80	—	—
	2	334	111	127	175	191	143	80	32
	3	175	16	32	16	143	95	48	64
	4	111	16	16	32	79	207	223	191
	$\bar{x}$	181	59	107	115	130	131	88	72
Melicytus ramiflorus	1	119	53	80	93	27	—	—	—
	2	80	111	143	49	32	—	—	—
	3	48	16	—	32	—	—	—	—
	4	32	16	—	—	—	—	—	—
	$\bar{x}$	70	49	56	43	15	—	—	—
Other species	1	93	40	53	92	26	79	58	13
	2	64	32	48	64	143	64	80	—
	3	96	32	16	—	—	16	—	—
	4	68	80	—	32	—	—	48	48
	$\bar{x}$	80	46	29	47	42	40	186	15
Totals	1	809	597	1035	1352	1313	703	151	13
	2	955	709	875	829	1066	732	367	112
	3	2355	319	350	588	843	461	287	175
	4	1369	319	255	366	668	764	509	319
	$\bar{x}$	1372	486	629	784	972	665	329	155

local seed sources of component trees. Kahikatea (*Dacrycarpus dacrydioides*) is found in the gully on the north-west margin of the mire, and *Syzygium maire* and pukatea (*Laurelia novae-zelandiae*) both occur within the Taupo catchment. Other species — such as mahoe, fuchsia (*Fuchsia excorticata*), kaikomako (*Pennantia corymbosa*), five-finger (*Pseudopanax arboreus*), and cabbage tree (*Cordyline australis*) — are also found beside or within the mire. Seed dispersal of these species should be adequate, as blackbird (*Turdus merula*) and silver eye (*Zosterops lateralis*) are common, and the seedlings of several bird-dispersed trees are found in the mire, remote from seed sources (for example, five-finger, kahikatea, fuchsia, kaikomako, and mahoe).

Major deviation from the successional trends identified here would arise if there were substantial changes in the local conditions. In particular, the re-introduction of stock would permit the further establishment of exotics such as pussy willow and blackberry, and any draining of the mire, or substantial alluvial deposition, would permit the development of mire shrubland and eventually forest.

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APPENDIX 1 — Abbreviated descriptions of vegetation types

The following terms are used for cover values: dense (>75% cover), close (50–75%), open (25–49%), scattered (10–24%, clumped), sparse (10–24%, dispersed), and occasional (only used for emergent plants, <10%). Figures in parentheses are stratum heights (in metres) of the upper summer foliage.

Pteridium fernland (fl): dense *Pteridium esculentum* (2.0); over sparse *Arrhenatherum elatius* (0.9); on raised terraces.

Phormium/Pteridium tussock fernland (f2): open *Phormium tenax* (3.0); over dense *P. esculentum* with sparse *Muehlenbeckia complexa* (2.0).

Pteridium/Dactylis grass fernland (f3): dense *Pteridium esculentum* (1.0); over open *Dactylis glomerata* and other grasses (0.5).

Festuca-Holcus grassland (g1): occasional *Carex lessoniana* (1.3); over dense *Holcus lanatus, Festuca arundinacea* and other grasses (1.1).

Carex/Holcus tussock grassland (g2): scattered *Carex secta* (2.0); over open *Bidens frondosa, Carex lessoniana,* and *Dactylis glomerata* (1.0); over open *Holcus lanatus* (0.6).

(Foeniculum)/Dactylis–Festuca herb grassland (g3): open *Foeniculum vulgare* (2.1); over dense *Dactylis glomerata, Festuca arundinacea,* and other grasses (1.5).

Scirpus–Mimulus–Polygonum sedge herbfield (h1): occasional *Phormium tenax* and *Cortaderia toetoe* (3.0); over occasional *Bidens frondosa* and *Carex lessoniana* (1.5); over dense *Scirpus prolifer, Mimulus guttatus, Polygonum* sp. and other low-growing species (1.0).

(Bidens/Festuca–Ranunculus) grass herbfield (h2): open *Bidens frondosa* (1.8); over open *Festuca arundinacea* and *Ranunculus repens* (1.1); over sparse mat of low-growing herbaceous species (0.3).

Bidens herbfield (h3): dense summer-green growth of *Bidens frondosa* (2.1); over scattered *Carex lessoniana* with close understorey of dead *C. secta* and dead *Pteridium esculentum* (1.3).

Mixed sedge herbfield (h4): areas of scattered to dense *Phormium tenax, Cortaderia toetoe, Typha orientalis, Lupinus arboreus,* or *Carex lessoniana* (2.5); locally over open *Carex secta, C. lessoniana,* and *Mentha* × *piperita,* with *Holcus lanatus, Glyceria declinata,* and other herbaceous species beside stream channels (0.8).

(Phormium–Typha)/Baumea–Carex tussock sedgeland (s1): scattered *Phormium tenax* and *Typha orientalis* (3.8); over dense *Baumea rubiginosa, Carex secta,* and *C. lessoniana* (2.0).

(Phormium–Cortaderia)/Baumea tussock sedgeland (s2): scattered *Cortaderia toetoe, Phormium tenax* and *Typha orientalis* (2.5); over close *Baumea rubiginosa* with *Blechnum minus* and *Carex secta* (2.0).

Phormium/Carex–Calystegia tussock sedgeland (s3): open *Phormium tenax* (3.0); over close *Carex lessoniana* overgrown by *Calystegia sepium* (2.0).

Phormium/Carex tussock sedgeland (s4): open *Phormium tenax* (3.0); over dense *Carex lessoniana* with scattered *C. secta* and grasses (1.0).

Typha/Carex reed sedgeland (s5): open *Typha orientalis* (3.0); over close *Carex lessoniana* with scattered *C. secta* and grasses (1.5).

Carex sedgeland (s6(1)): dense *Carex lessoniana* (1.8); over sparse *Holcus lanatus* and herbaceous species (0.5).

Carex/Ranunculus herb sedgeland (s6(2)): dense *Carex lessoniana* with scattered *Juncus sarophorus* (2.0); over open *Ranunculus repens* with other herbaceous species and grasses (0.3).

Carex herb sedgeland (s6(3)): scattered *Juncus gregiflorus* and *J. sarophorus* (2.0); over close *Carex lessoniana* with sparse *Agrostis stolonifera* (1.0); over sparse *Ranunculus repens* and other herbaceous species (0.5).

Rubus scrub (sh1): dense cover of *Rubus fruticosus* with sparse *Pteridium esculentum* (3.0).

Muehlenbeckia/Poa grass shrubland (sh2): sparse *Phormium tenax* (2.5); over dense *Muehlenbeckia complexa* intermingled with and over *Poa anceps* (1.5).

(Salix)/Muehlenbeckia–Poa grass shrubland (sh3): sparse to scattered *Salix atrocinerea* (6.0); over open *Phormium tenax* and *Coprosma robusta* (2.5); over close *Muehlenbeckia complexa* with sparse *Poa anceps* (1.5); sparse *M. complexa* also covering upper strata locally.

Leptospermum/Coprosma–Pteridium fern shrubland (sh4): open *Leptospermum scoparium* (5.5); over open *Coprosma robusta* and *Pteridium esculentum* (2.0).

Phormium tussockland (t1): close to dense *Phormium tenax* with scattered *Coprosma robusta* and *Hebe stricta* (3.0); over scattered *Carex secta* (2.0).

Phormium–Cortaderia/Carex sedge tussockland (t2): close *Phormium tenax* and *Cortaderia toetoe* with scattered *Coprosma robusta* (2.5); over close *Carex secta* and *C. lessoniana* (1.0).
(Phormium)/Carex–Baumea sedge tussockland (t3): open *Phormium tenax, Cortaderia toetoe,* and *Typha orientalis* (3.0); over close *Carex secta* and *Baumea rubiginosa* (2.0).
Salix/Mentha herb treeland (tr): close *Salix fragilis* (10.0); over close ground cover of *Mentha* × *piperita* (0.5).

APPENDIX 2 — List of vascular plant species

Included are all vascular species — both from the mire proper and the adjacent, lower hill slopes — recorded between State Highway 1, the Main Trunk railway, Airlie Road, and Winstone's factory. Common names are shown in parentheses, as are also taxonomic notes. Symbols used: + = present in mire proper; * = exotic to New Zealand; † = indigenous New Zealand species but adventive to the Wellington district; — = rare in survey area (observation based on fewer than five individuals, or colonies of total area not greater than 5 m^2). Except where authorities are cited, nomenclature follows Allan (1961), Moore & Edgar (1970), New Zealand Weed and Pest Control Society (1969), Edgar (1971), and Healy & Edgar (1980), the last two taking priority. Numbers refer to herbarium specimens deposited in the Department of Botany herbarium, Victoria University of Wellington (WELTU) and Botany Division herbarium, DSIR (CHR).

1. Trees and shrubs

Acacia floribunda (golden wattle) * —
Albizzia lophantha * —
Brachyglottis repanda (rangiora)
Carmichaelia arborea var. (New Zealand broom) +
Cassinia leptophylla (tauhinu)
Chamaecytisus palmensis (Christ.) Hutch. (tree lucerne) + *
Chrysanthemodes moniliferum (L.) Norlindh. (stone seed) * —
Coprosma areolata +
C. propinqua (incl. var. *latiuscula*) —
C. repens (taupata) —
C. rhamnoides +
C. robusta (karamu) +
C. tenuicaulis +
C. propinqua × *C. robusta* —
Cordyline australis (cabbage tree) + —
Coriaria arborea (tree tutu) +
Crataegus sp. (hawthorn) * —
Cupressus macrocarpa (macrocarpa) * —
Cytisus scoparius (broom) + *
Dacrycarpus dacrydioides (kahikatea) + —
Fuchsia excorticata (tree fuchsia) +
Geniostoma rupestre A. Rich. var. (hangehange) +
Hebe stricta var. *atkinsonii* (koromiko) +
Hydrangea macrophylla Ser. (hydrangea) + * —
Hypericum androsaemum (tutsan) + * —
Knightia excelsa (rewarewa) —
Leptospermum ericoides (kanuka) +
L. scoparium (manuka) +
Leucopogon fraseri A. Cunn. (patotara)
Lophomyrtus bullata (ramarama) —
Lupinus arboreus (tree lupin) + *
Malus domestica (apple) + *
Melicytus ramiflorus (mahoe) +
Myoporum laetum (ngaio) —
Olearia rani (heketara) +
O. solandri + —
Paratrophis microphylla (milk tree) —
Pennantia corymbosa (kaikomako) +
Pimelea prostrata var. *prostrata* —
Pinus radiata (radiata pine) * —
Pittosporum crassifolium (karo) + † —
P. tenuifolium (kohuhu) —
Populus nigra cv. 'Italica' (Lombardy poplar) + * —
Prunus domestica L. (plum) * —
P. persica Batsch (peach or nectarine) * —
Pseudopanax arboreus (Murr.) Philipson (five-finger) +
P. crassifolius (A. Cunn.) C. Koch (lancewood) +
P. lessonii (DC.) C. Koch (coastal five-finger) † —
Pyrus communis (pear) * —
Salix atrocinerea Brot. (pussy willow) + *
S. fragilis (crack willow) + *
Sambucus nigra (elder) + *
Solanum laciniatum (poroporo) +
S. pseudocapsicum (Jerusalem cherry) + *
Sophora sp. (*S. microphylla* × *S. tetraptera*?) (kowhai) † —
Teline monspessulana (L.) Koch (Montpellier broom) + *
T. stenopetala (Webb et Berth.) Webb et Berth. + *
Ulex europaeus (gorse) + *
Ulmus × *hollandica* Mill. (elm) + * —
Urtica ferox (tree nettle)
Weinmannia racemosa (kamahi) —

2. Woody lianes

Calystegia tuguriorum +
Calystegia sp. (*C. sepium* agg.) (with white-striped, pink flowers) (greater bindweed) + 12781 (WELTU)
Calystegia sp. (*C. sepium* agg.) (with pure white flowers) (greater bindweed) +
Clematis forsteri (including *C. hookeriana*) (clematis) —
C. paniculata (clematis) —
Lonicera japonica (Japanese honeysuckle) + *
Metrosideros diffusa (white rata) —
M. perforata (white rata) —
Muehlenbeckia australis (bush pohuehue) +
M. complexa (pohuehue) +
M. australis × *M. complexa* (pohuehue) +
Parsonsia heterophylla (New Zealand jasmine) +
Ripogonum scandens (supplejack) —
Rubus australis (bush lawyer) —
R. cissoides (bush lawyer) +
R. fruticosus (blackberry) + *
R. laciniatus (blackberry) * —
Rubus sp. (*R. phoenicolasius*? (Japanese wineberry)) * —
R. australis × *R. cissoides* (bush lawyer) —
Senecio angulatus (Cape ivy) * —
S. mikanioides (German ivy) *
Solanum dulcamara (bittersweet) + * 12782 (WELTU)
Tetrapathaea tetrandra (native passion flower) + —

3. Dicotyledonous herbs and sub-shrubs

Acaena anserinifolia (piripiri) +
Achillea millefolium (yarrow) *
Amaranthus deflexus (prostrate amaranth) * — 12787 (WELTU)
Anagallis arvensis (scarlet pimpernel) *
Anthemis cotula (stinking mayweed) * —
Arctium lappa (burdock) * —
Aster subulatus (sea aster) * 12776 (WELTU)
Barbarea sp. (*B. verna*?) (winter cress) * —
Bidens frondosa (beggars' ticks) + * 12773 (WELTU)
Brassica rapa L. ssp. *sylvestris* (L.) Janchen (wild turnip) + *
Callitriche stagnalis (starwort) + *
Cardamine flexuosa (wavy bitter cress) + *
Cardamine sp. (*C. debilis* agg.) (bitter cress)
Carduus tenuiflorus (winged thistle) *
Centaurium erythraea (centaury) *

Centella uniflora (centella) +
Cerastium glomeratum (annual mouse-ear chickweed) + *
C. fontanum Baumg. ssp. *triviale* (Link) Jalas *
Chenopodium album (fathen) * —
C. murale (nettle-leaved fathen) * —
Cirsium arvense (Californian thistle) + *
C. vulgare (scotch thistle) + *
Conium maculatum (hemlock) + *
Coronopus didymus (twin cress) *
Cotula australis *
C. coronopifolia (batchelor's button) + *
Crepis capillaris (hawksbeard) *
Cryptostemma calendula (Cape weed) *
Digitalis purpurea (foxglove) + *
Drosera peltata Thunb. ssp. *auriculata* (Planchon) Conn
Epilobium pallidiflorum (willowherb) + 12779 (WELTU)
Erigeron floribundus (broad-leaved fleabane) + *
Erodium moschatum (storksbill) *
Euphorbia peplus (milkweed) + *
Foeniculum vulgare (fennel) + *
Fumaria muralis (scrambling fumitory) *
Galega officinalis (goat's rue) + *
Galium aparine (cleavers) + *
G. propinquum
G. trilobum Col. (petiolate form) + 12783 (WELTU)
G. trilobum Col. (apetiolate form) + 12784 (WELTU)
Geranium dissectum (cut-leaved geranium) * —
G. microphyllum
G. molle (dove's foot) *
Gnaphalium audax Drury (cudweed)
G. gymnocephalum (cudweed)
G. involucratum Forst.f. (cudweed) — 12778 (WELTU)
G. spicatum Lam. (cudweed) *
Gnaphalium sp. (*G. luteo-album* agg.) (cudweed)
Gonocarpus montanus (Hook.f.) Orchard —
Haloragis erecta (shrubby haloragis) +
Hydrocotyle americana (waxweed) + —
H. moschata (hydrocotyle) —
H. sp. (*H. novae-zelandiae* agg.) (hydrocotyle) +
Hypochoeris radicata (catsear) + *
Lactuca serriola var. *integrata* * — 366 709 (CHR)
Lathyrus sp. [*L. latifolius*? (everlasting pea)] + *
Leontodon taraxacoides (hawkbit) *
Lepidium bonariense L. (narrow-leaved cress) * 366 710 (CHR)
Linaria purpurea (purple linaria) *
Linum bienne Mill. (pale flax) * —
Lotus pedunculatus (lotus major) + *
L. subbiflorus (hairy lotus) *
Lythrum hyssopifolia (loosestrife) + *
Malva sp. (mallow) *
Matricaria matricarioides (rayless chamomile) *
Medicago arabica (spotted burr medick) *
M. lupulina (black medick) * —
M. polymorpha (burr medick) *
Melilotus indica (King Island melilot) * —
Mentha × *piperita* (peppermint) + * 12789 (WELTU)
M. × *villosa* Huds. + * —
Mimulus guttatus (monkey musk) + *
Modiola caroliniana (creeping mallow) + *
Myosotis caespitosa (water forget-me-not) + *
Nasturtium microphyllum (Boenn.) Reichenb. (watercress) + *
Orobanche minor (broomrape) * —
Oxalis articulata * —
Oxalis sp. (yellow-flowered) * ?
Papaver somniferum ssp. *somniferum* * — 366 712 (CHR)
Parentucellia viscosa (L.) Caruel (tarweed) *
Pelargonium inodorum — 366 711 (CHR)
Petroselinum crispum (wild parsley) * —
Picris echioides (oxtongue) *
Pisum sativum L. (garden pea) *
Plantago coronopus (buck's-horn plantain) *
P. lanceolata (narrow-leaved plantain) *
P. major (broad-leaved plantain) *
Polycarpon tetraphyllum (allseed) *
Polygonum aviculare (wireweed) *
P. hydropiper (water pepper) + *
P. persicaria (willow weed) *
P. sp. (*P. decipiens* auct. N.Z.) (swamp willow weed) +
Ranunculus hirtus (bush buttercup)
R. macropus + —
R. repens (creeping buttercup) + *
R. sceleratus (celery-leaved buttercup) + * —
Raphanus raphanistrum (wild radish) + *
Rumex acetosella (sheep's sorrel) + *
R. conglomeratus (clustered dock) + *
R. crispus (curled dock) + *
R. obtusifolius (broad-leaved dock) + *
R. sagittatus (climbing dock) + *
Sagina apetala * —
S. procumbens (pearlwort) *
Senecio bipinnatisectus Belcher (fireweed) * 12774 (WELTU)
S. glomeratus Desf. *ex* Porret (fireweed) + 12775 (WELTU)
S. hispidulus A. Rich. (fireweed)
S. jacobaea (ragwort) + *
S. quadridentatus Labill. —
S. spathulatus A. Rich. *
S. vulgaris (groundsel) *
Silene gallica (catchfly) *
Silybum marianum (variegated thistle) *
Sisymbrium orientale (oriental mustard) * — 12786 (WELTU)
Solanum nigrum (black nightshade) + *
S. nodiflorum (small-flowered nightshade) +
S. sublobatum Willd. (velvety nightshade) + *
Sonchus asper (prickly sow thistle) + *
S. oleraceus (sow thistle) + *
Spergula arvensis (spurrey) *
Spergularia rubra (sand spurrey) *
Stachys arvensis (staggerweed) *
Stellaria media (chickweed) + *
S. parviflora
Tetragonia trigyna (New Zealand spinach) —
Trifolium arvense (haresfoot trefoil) *
T. dubium (suckling clover) *
T. pratense (red clover) * —
T. repens (white clover) + *
T. subterraneum (subterranean clover) *
Tropaeolum majus (garden nasturtium) + * —
Urtica incisa —
U. linearifolia (New Zealand swamp nettle) + 12779 (WELTU)
Veronica arvensis (field speedwell) *
Veronica sp. (*V. serpyllifolia*? (turf speedwell)) * —
Vicia hirsuta (hairy vetch) + *
V. sativa (vetch) + *

4. Sedges

Baumea rubiginosa +
B. tenax +
Carex breviculmis —
C. dissita + —
C. flagellifera +
C. geminata (rautahi) +
C. lessoniana (rautahi) +
C. maorica + — 12785 (WELTU)
C. secta var. *secta* (niggerhead) +
C. solandri
C. virgata +

Carex sp. (unnamed sp. c.f. *C. testacea* & *C. raoulii*)
Cyperus eragrostis + * —
C. ustulatus +
Eleocharis acuta +
E. gracilis + —
Schoenus maschalinus + —
Scirpus nodosus —
S. platycarpus * —
S. prolifer +
S. reticularis —
S. setaceus * —
Uncinia uncinata (hooked sedge)

5. Rushes
Juncus articulatus (jointed rush) + *
J. australis +
J. bufonius var. *bufonius* (toad rush) + *
J. caespiticius —
J. effusus + *
J. gregiflorus +
J. pallidus +
J. planifolius +
J. sarophorus +
Luzula picta var. *picta* (wood rush)

6. Grasses
Agrostis stolonifera (creeping bent) + *
A. tenuis (browntop) *
Anthoxanthum odoratum (sweet vernal) + *
Arrhenatherum elatius (tall oat grass) + *
Avena sp.? (wild oat) + * —
Briza media L. (quaking-grass) *
Bromus diandrus (ripgut brome) *
B. mollis (soft brome) *
B. unioloides (prairie grass) + *
Cortaderia toetoe (toetoe) +
Cynosurus cristatus (crested dogstail) *
Dactylis glomerata (cocksfoot) + *
Dichelachne crinita (plume grass) —
Echinopogon ovatus (hedgehog grass)
Ehrharta erecta (veld grass) + * —
Festuca arundinacea (tall fescue) + *
Glyceria declinata (floating sweet grass) + *
G. maxima + * 12788 (WELTU)
Holcus lanatus (Yorkshire fog) + *
Lolium multiflorum (Italian ryegrass) + * 12772 (WELTU)
L. perenne (perennial ryegrass) + * 12772 (WELTU)
Microlaena stipoides (meadow rice grass)
Paspalum dilatatum (paspalum) *
Pennisetum clandestinum (kikuyu grass) * —
Phalaris sp. (canary grass) * —
Poa anceps Forst.f. +
P. annua (annual poa) *
P. laevis (silver tussock) —
P. trivialis + * —
Rytidosperma sp. (*R. racemosum* (R.Br.) Connor et Edgar?) (danthonia)
Sporobolus africanus (ratstail) *
Vulpia bromoides (hair grass) *

7. Orchids
Acianthus fornicatus var. *sinclairii* —
Caladenia catenata (Sm.) Druce —
Microtis unifolia (onion-leaved orchid)
Orthoceras strictum —
Pterostylis alobula (hood orchid) —
P. sp. (*P. graminea*?) (hood orchid) —
P. sp. (*P. montana?*) (hood orchid) + —
Thelymitra longifolia (sun orchid)
T. pauciflora (sun orchid) —

8. Other monocotyledonous herbs
Alisma lanceolatum (water–plantain) + * 12780 (WELTU)
Allium triquetrum (three-cornered garlic) + *
Canna indica (canna lily) * —
Crocosmia × *crocosmiiflora* (montbretia) *
Lemna minor (duckweed) + —
Phormium tenax (New Zealand flax) +
Potamogeton sp. (*P. crispus?* (curled pondweed)) + * —
Sisyrinchium iridifolium (blue-eyed grass) *
Tradescantia fluminensis (wandering Jew) + *
T. virginiana L. (purple spiderwort) * —
Triglochin striatum —
Tritonia sp. (*T. crocata* Ker-Gawl?) * —
Typha orientalis (raupo) +
Zantedeschia aethiopica (arum lily) + * —

9. Ferns and fern allies
Adiantum cunninghamii (maidenhair) —
Asplenium bulbiferum ssp. *bulbiferum* (hen & chicken fern)
A. flabellifolium
A. flaccidum ssp. *flaccidum* +
A. hookerianum (incl. *A. colensoi*)
A. oblongifolium Col. +
A. polyodon Forst.f. + —
Blechnum chambersii Tindale +
B. filiforme (climbing blechnum)
B. minus (R.Br) Ettingsh. (kiokio) +
Cyathea dealbata (ponga) +
C. medullaris (mamaku) +
Dicksonia squarrosa (wheki)
Histiopteris incisa (water fern) +
Hymenophyllum sp. (*H. dilatatum?*) (filmy fern) —
Hypolepis sp. (*H. tenuifolia* auct. N.Z.) +
Lastreopsis glabella +
Lycopodium volubile (climbing clubmoss)
Paesia scaberula (ring fern) +
Pellaea rotundifolia
Phymatosorus scandens (Forst.f.) Pic. Ser. —
Pneumatopteris pennigera (Forst.f.) Holttum +
Polystichum richardii
P. vestitum —
Pteridium esculentum (bracken) (Forst.f.) Cockayne +
Pteris pendula Col. (*C. macilenta* auct. N.Z., not *C. macilenta* s.s.) +
P. tremula
Pyrrosia serpens + —