LAKES MANAPOURI AND TE ANAU

MIRES OF THE MANAPOURI - TE ANAU LOWLANDS

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SUMMARY: This is a preliminary account of the wetlands near Lakes Manapouri and Te Anau, New Zealand. It discusses briefly the vegetational history of the area and describes the general nature and vegetation of certain of the mires.

TERMINOLOGY

We wish to avoid using terms which might be considered colloquial and imprecise or which have been given precise and fairly limiting definitions elsewhere. Therefore, throughout this paper, the terms 'wetland' and more especially 'mire' are employed. 'Wetland' is a general term for an ecosystem which has a water-table above, at, or just below the substrate surface so that the substrate is water-saturated for most of the year. 'Mire' is also a broad term and is used when referring to specific wetland sites carrying any type of macrophytic vegetation. It has had widespread use elsewhere, particularly by Scandinavian workers (e.g. Sjörs 1950). Mires are defined as areas where excessive water is the major influence on plant growth. For a variety of reasons most species which occur in mires cannot survive in well drained or periodically dry sites. Godwin and Conway (1939, p.313) restrict the term as "embracing all kinds of peat lands and all kinds of peat land vegetation", but we prefer to extend it to encompass vegetated wetland sites where little or no peat accumulation has occurred. Terms such as 'bog', 'fen', 'swamp' etc. are avoided since there is insufficient information to permit clear definition of New Zealand wetland types.

'Deposit' is a general term used to refer to material which has accumulated on a wetland site. 'Sediment' refers to any material, organic or inorganic, which has accumulated allochthonously or autochthonously. Autochthonous deposits are sometimes differentiated from sediments proper but it is often difficult, in considering the stratigraphy of deposits of a mire, to distinguish between those elements which have been derived *in situ* and those which have been derived elsewhere (see e.g. West 1968).

THE LOCALITY AND HISTORY OF THE WETLANDS

Lakes Manapouri and Te Anau lie on the eastern margin of the hard rock highland of Fiordland, their basins partially surrounded by steep mountainsides cut into Palæozoic gneisses and granites. The lakes drain by way of the Waiau River into the Te Anau basin, a depression containing soft sediments of Tertiary and Quaternary age (Wood 1962, 1966). The floor of the basin ranges from 180m to about 270m a.s.l., with higher ridges rising to 400m and a few hills up to about 600m. There are extensive areas of wetland round the south-eastern ends of the lakes (Fig. 1). The wetlands have arisen mainly on landforms resulting from the widespread glaciation of the area. A detailed account of all the sites which we studied and of the conditions leading to the development of the wetlands cannot be given here but the following general sequence of events has occurred and some specific sites are described more fully later.

During the Otiran glaciation there were multiple advances and retreat phases of the great glaciers which lay in the depressions now occupied by Lakes Manapouri and Te Anau (Dr I. C. McKellar pers. comm.). These gave rise, in the Te Anau Basin, to extensive tracts of glacial drift which now form rolling terrain. These downland areas are separated by outwash plains and river channels formerly occupied by melt-

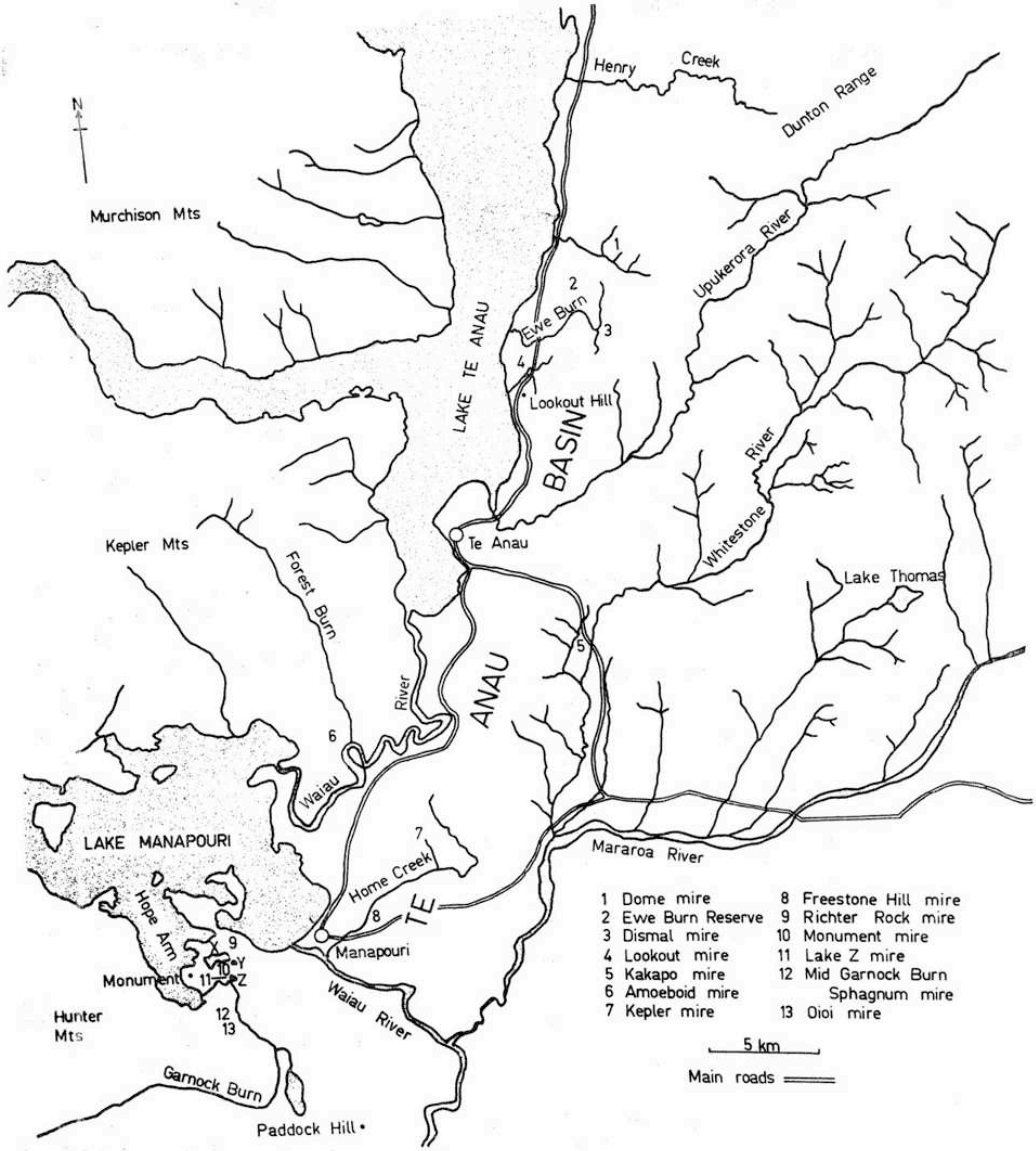

FIGURE 1. *Locality map for the mires described in the text.*

water streams. Some of the channels are occupied by modern rivers and streams which, by down-cutting, have formed series of terraces. Drainage was (and continues to be) impeded in many places. These ranged from relatively level sites such as the old river channels and oxbows, and terraces adjoining streams, to depressions of various sizes on the downlands. Many of the latter carried impermanent seepages and pools but many were permanently water-filled, giving rise to ponds, larger lake basins and lagoons marginal to the main lakes.

Deposits began to accumulate in the areas of impeded drainage in many instances at least as long ago as the close of the last Otiran glacial advance, approximately 14,000 years B.P. (Suggate and Moar 1970). The development of various kinds of sedimentary deposits has taken several forms. Commonly, ponds and lakes have been partially or wholly infilled, firstly by lake sediments (often partly inorganic) and later by peat. In some larger lakes there has been vegetation and peat development only at the margins. Accumulation of peat, without a marked open-water phase, has occurred in old river channels and on some terraces. Some other surfaces are waterlogged but there has been little peat accumulation. The processes of sedimentation continue in many sites.

It is likely that wetland development was linked to general vegetation development in the area, but both were affected by climate. Wood and seeds of tree species are present in several of the peat deposits which we have examined. When describing the results of pollen analysis of samples from the Richters Rock and Freestone Hill sites (Fig. 1), Cranwell and von Post (1936) outlined the course of post-glacial vegetation changes in the region. There are, however, no dates for the three main phases in vegetation development which they discovered.

All of the wetland areas in the region were once surrounded by forest, but beyond the south-eastern ends of the lakes most of it has been destroyed by fire, in part during the period of Polynesian occupation, but partly in the last hundred years. Charcoal is abundant in the soil and the soils of the Te Anau basin everywhere show unmistakable signs of forest influence. The forests were succeeded by shrubland and fernland, primarily dominated by *Leptospermum scoparium* or *Pteridium esculentum,* but many other species contributed to the vegetation and there were extensive areas of tussock grassland dominated by *Chionochloa rubra* or, on drier sites, *Festuca novae-zelandiae* and *Poa colensoi.*

The soils of the region were probably never very fertile, except where they were developed on certain marine sediments, and a notable feature on many of the downland areas is extreme soil poverty, often accompanied by gleying and podsolization. Phosphorus and cations are lacking and land development for farms in the area has required the application of large amounts of phosphatic fertilizer. Elsewhere, seepage water accumulates plant nutrients and conditions are more fertile. Relative differences in fertility have probably contributed to the pattern of wetland development.

Garnier (1958) described the climate of the Southland lowlands as being cloudy, with low sunshine values and temperatures lower at all seasons than other lowland areas in New Zealand. Winters may be described as cold and summers cool, but nevertheless extreme minimum temperatures are not markedly low for Otautau, the nearest station to the Te Anau Basin with sunshine records (75km distant to the south-east).* Rainfall is reliable and evenly distributed. Very few data are available for the Te Anau Basin; its summer maximum temperatures appear to be higher and winter minimum temperatures lower than those of Otautau and other lowland stations in Southland which are less enclosed in inland basins (cf. records for Mid Dome, another adjacent station 64km to the east).*

The Te Anau Basin probably receives more bright sunshine in summer than Otautau and, although precipitation is greater, number of rain

* New Zealand Meteorological Service 1966: "Summaries of Climatological Observations at New Zealand Stations to 1960"; and "Meteorological Observations" for the years 1961-1969. Government Printer, Wellington.

days is less, so that evaporation is probably greater. However, maximum summer temperatures are lower, total precipitation more, numbers of rain days more, total sunshine hours less and evaporation less than for inland stations further north, such as Queenstown or Lake Coleridge in the Wakatipu and Rakaia basins, respectively.

It is likely that marked climatic variations have occurred in the region during the post-glacial period. We have the impression that the vast development of wetlands might not have occurred if the climate had always been as dry in summer as it has in recent years. We infer that a continually humid, relatively cool environment is necessary for the development of extensive raised peat mires such as occur in the region. No such peat development is found in places of similar age and terrain further north (e.g. in the Lake Wakatipu or Rakaia regions). As it is, the wetlands are self-sustaining to a very large extent and can outlast periods of unfavourable climate.

Details of post-glacial climatic change in New Zealand are elusive and interpretation is difficult (see Moar 1971) but we subscribe to the conclusions of Cranwell and von Post (1936), in that their results can mainly be interpreted in terms of climatic changes, at least in this region. Further unpublished pollen analyses by other workers from the same area support these conclusions.

AIMS OF THE STUDY

Initially the study was aimed at investigating areas which would be affected if Lake Manapouri was raised. Work was begun in 1970 round Lake Manapouri. The purpose was to record details of the wetland vegetation which would be submerged if the lake was raised by about 8m. Adjacent areas whose hydrology might be affected by the raised water level were also investigated. Descriptions of the wetlands and their vegetation and some borings into the sediments were made. It was soon realised that, to understand the general ecology of the wetlands, areas more distant from the lake would need to be examined.

The programme was expanded in 1971 to include wetlands in the Te Anau basin affected by farming development. Areas immediately around Lakes Manapouri and Te Anau were studied as well as various other wetlands as far away as Lake Thomas, near the Mararoa river and a site near Knobs Flat in the Eglinton valley. Further vegetation sampling was done and Dr N. Moar and V. Miers obtained samples of sediments for pollen analysis. Although there are many areas still uninvestigated and although our knowledge of the environment and stratigraphy of the wetlands is very limited, we now feel in a position to make preliminary general statements about the nature of the vegetation and its ecology. This is the first of these accounts and the results of vegetation analysis will be presented elsewhere.

METHODS

A quantitative record of the shorter vegetation of the wetlands was made by point analysis. Samples were taken at random from stands of physiognomically uniform vegetation. At each sampling site first hits were recorded for two hundred points taken on a U-shaped traverse using a point frame set with vertically mounted points at five centimetre intervals. The number of hits recorded for each species was converted to give the percentage cover of that species. Species seen along the line of the transect but not hit were recorded as present. Areas of shrubby vegetation taller than one metre were avoided. Extended legs were added to the point frame in taller vegetation. Details of the site and other relevant notes were recorded. Ninety-six stands of vegetation were examined and the data have been transferred from the plot sheets to punched cards for analysis, the results of which will be published separately.

The validity and usefulness of point analysis as a method of estimating cover has been discussed by Goodall (1952) and Greig-Smith (1964). This method will certainly have produced some distorted results particularly with those species with thin, vertical stems such as *Baumea rubiginosa*. The importance of this type of plant in a stand will appear to be lower than it actually is. However, of the non-destructive methods of analysis known to us, this provided the most satisfactory way of assessing importance of a species in a community.

Taller, woody vegetation on the mires and the vegetation of the mire margins, where it is still intact, were measured by means of belt transects, 3m wide, in units 20m long. These were laid out at right angles to the margins of the mires, or, rarely, in the middle of some mires; and counts of discrete plants were made for each height class (< 0.6m, 0.6-1.5m, 1.5-3.0m, 3-6m, > 6m). Diameters, at 1m height, of the trunks of plants over 6m high were recorded. If plants were very numerous or not discrete they were recorded as "infinite". Twenty-four samples of this type were made.

Levelling across the surfaces of several mires was done with staves and abney levels and, once, with a dumpy level. Boring, to obtain samples for pollen analysis and to record the stratigraphy of the sediments, was done with hiller peat borers.

GENERAL DESCRIPTION OF MIRES

The origins, general form, margin profile, surface form, stratigraphy and the physiognomy of the vegetation of a few individual mires are described here. The vegetation varies between sites and, although in some this is clearly due to differences in amounts of water present, in others it is more likely to be in response to differences in available nutrients and water movement. The larger mires frequently have a mosaic of vegetation types reflecting changing environmental conditions across their surfaces. Small mires tend to have rather uniform vegetation. There is also a tendency for each to have a unique vegetation.

1. *Mid Garnock Burn Sphagnum Mire*

This is a small mire formed in a shallow lake basin between the flood plain levee of the Garnock Burn and moraine ridges. The stratigraphy was not investigated in detail but the sediments are at least 490cm deep and consist largely of soft *Sphagnum* peat. The bog surface is very wet and is horizontal (gently sloping at its northern end). The vegetation is dominated by *Sphagnum* species, and the percentage cover, by species, is given in Table 1.

Near the margins some other species become slightly more prominent and there is usually a shrubbery consisting of *Leptospermum scoparium*, *Phyllocladus alpinus* and *Dacrydium bidwillii*. As in several other instances in which a rim of shrubs surrounds a very wet mire, the plants are only about 30 to 60cm high on the mire side, increasing to more than 6m on the side facing dry land. The shrubbery quickly merges, on drier land, into a forest of *Nothofagus solandri* var. *cliffortioides* with scattered *Podocarpus dacrydioides*.

TABLE 1. *Summary of Species Composition of the Vegetation of Mid Garnock Burn Sphagnum Mire* (Sample 71/33).*

Species	Cover (%)
Sphagnum cristatum	37
Sphagnum falcatulum	42
Calorophus minor	6
Oreobolus strictus	5
Oreobolus pectinatus	5
others	5

2. *Richters Rock Mire*

This moderately large mire is formed in a lake basin enclosed by moraine ridges. Peat and shallow lake sediments fill the basin to a depth of at least 650cm. The stratigraphy is given in Appendix I.

The mire proper carries a "parkland" vegetation of scattered bushes of *Leptospermum scoparium* up to about 3m high with a short turf forming the cover between (Table 2, Fig. 2).

TABLE 2. *Summary of Species Composition of the Vegetation of Richters Rock Mire (Sample 70/7).*

Species	Cover (%)
Calorophus minor	19
Dicranoloma billardieri	22
Sphagnum falcatulum	16
Oreobolus strictus	5
Baumea tenax	10
Baumea rubiginosa	5
mud	6
litter	6
others	11

* In this table and all similar tables which give summaries of species composition, only the prominent species, those forming 5% or more of the cover, are listed.

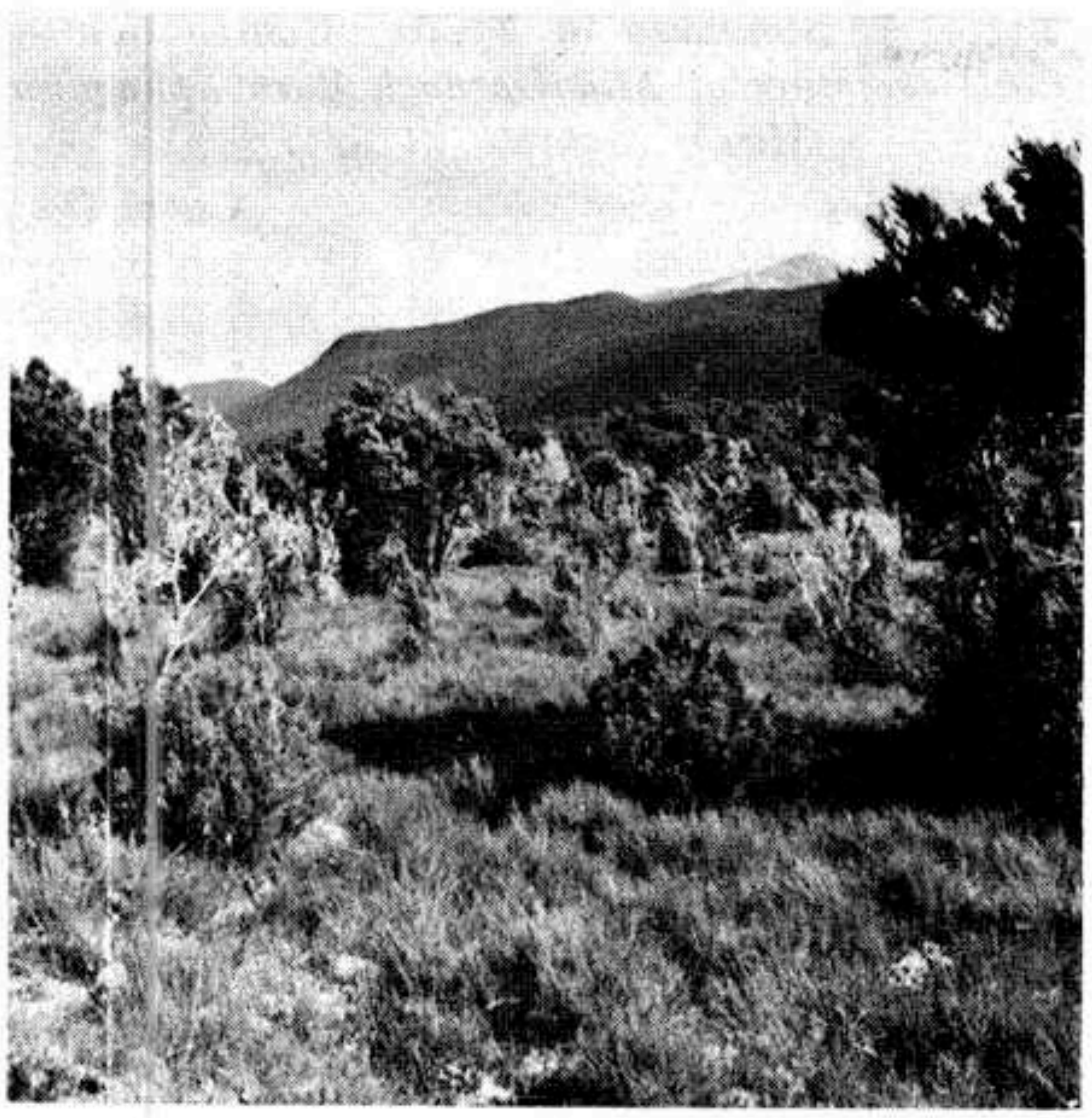

FIGURE 2. *Richters Rock mire.* Leptospermum scoparium *and* Dacrydium bidwillii *bushes are scattered in a ground cover of* Calorophus minor, Baumea tenax *and some* Cladonia *cf.* leptoclada.

Round each *Leptospermum* bush, as in other mires of this type, there is a "mound" of long *Calorophus* stems, abundant *Cyathodes empetrifolia* and occasional *Gleichenia dicarpa*. The areas between carry a mosaic of small, well vegetated hummocks with *Baumea tenax, Dicranoloma billardieri, Sphagnum cristatum, Cladonia* cf. *leptoclada, Oreobolus strictus* and, in places, *Eucamptodon inflatus*. These alternate with shallow, water-filled hollows in which algal mud, *Sphagnum falcatulum* and sparse, stunted *Baumea rubiginosa* are present. The mire surface is generally horizontal but a raised peat surface spills down a slope at the southern margin.

Transect data (Appendix II and Figure 3) illustrate the vegetation pattern at the edges of the forest-surrounded mire and show the depths of peat. Very similar patterns are present at the margins of other mires, although, where slopes are less steep, *Podocarpus dacrydioides* is usually present.

This mire is the site of one of the classical studies by Cranwell and von Post (1936).

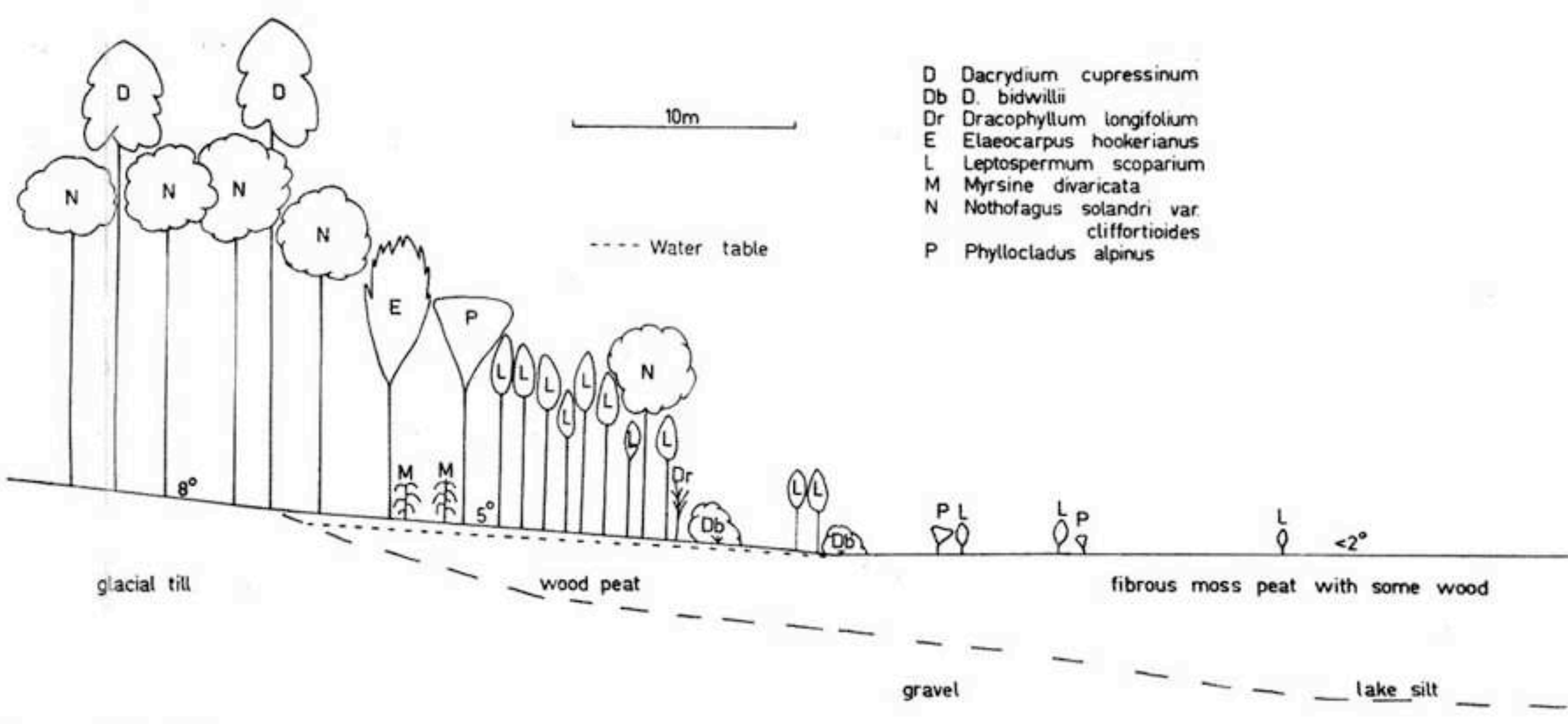

FIGURE 3. *Diagram of vegetation at the margin of Richters Rock mire. Similar patterns occur round other forest-surrounded mires. The vegetation is drawn to scale except for plants below 2m in height. The water table, recorded in February 1971, was at a depth of 45cm beneath the* Dacrydium cupressinum *trees, rising to 3cm below the surface on the mire proper.*

c. *Monument Mire*

A large, complex mire surrounding two lakes, Monument mire is formed in a lake basin marginal to Lake Manapouri. A high water table was maintained, initially, by a moraine ridge and by the formation of flood-plain levees by the Garnock Burn and one of its tributaries. The sediments in the basin are at least 700cm thick and the stratigraphy is given in Appendix I.

FIGURE 4. *Monument mire. In the foreground* Calorophus minor-Baumea tenax *dominated vegetation. In the background the mire margin with a band of tall* Leptospermum scoparium *and then* Nothofagus solandri *var.* cliffortioides *forest with emergent* Dacrydium cupressinum, Podocarpus dacrydioides *and* P. spicatus *trees. The Monument lies beyond this.*

The margins and some of the surface of the mire have vegetation similar to that found on the Richters Rock mire (Appendix II) but there are wide, open stretches with no *Leptospermum* and rather diverse vegetation (Fig. 4, Table 3). The mire has an almost horizontal surface and the level of lakes X and Y is almost flush with it. Especially near the lakes there are elaborate small pool and hummock systems. The surfaces of these areas quake as one moves across them. The pools usually carry stunted *Baumea rubiginosa* and dense algal mud. The hummocks have zoned patterns of vegetation. A common sequence is: *Sphagnum falcatulum* nearest the water, *S. cristatum, Drosera binata* and *D. spathulata* on the sides of the hummock, then *Calorophus minor* and *Baumea tenax* with *S. cristatum,* and finally the summit is capped by *Dicranoloma billardieri*. The patterns are diverse, however, and some hummocks consist of tussocks of *B. tenax* or *Calorophus* (Fig. 5). Various other species including *Cladonia* cf. *leptoclada, Eucamptodon inflatus* and *Campylopus spp.* may also be present

FIGURE 5. *Small-scale pool and hummock system, Monument mire. The pools are filled with blue-green algae and the hummocks have diverse vegetation in which* Calorophus minor *and* Baumea tenax *are prominent.*

The edges of the lakes descend vertically or nearly so for up to 5m in many places but, wherever the water is relatively shallow, a band of *Eleocharis sphacelata,* or *Baumea rubiginosa* or both, up to 2m tall, is present (Fig. 6). A common situation at the lake edges is the presence of a levee, possibly due partly to wave action, partly to increased fertility. The levee has a taller growth of plants, forming a slightly raised, firmer root mat than in the area immediately on its landward side (Fig. 7). *Leptospermum, Calorophus* and *Gleichenia dicarpa* are common here, but in a few places *Carex secta* and *Phormium tenax* occur. At the western end of Lake X there

TABLE 3. *Summary of Species Composition of Two Samples of Vegetation of Monument Mire.*

Sample 70/12	Cover (%)
Calorophus minor	56
Baumea tenax	10
Lepidosperma australe	8
mud	9
litter	6
water	4
others	7
Sample 70/20	**Cover (%)**
Calorophus minor	17
Baumea tenax	7
Lycopodium ramulosum	8
Dicranoloma billardieri	9
Sphagnum cristatum	19
Sphagnum falcatulum	8
mud	10
litter	9
water	10
others	3

is a quaking mire dominated by *Sphagnum falcatulum* behind this levee. The height and density of *Leptospermum* increases toward dry land at the margin of the mire and along some sluggish streams flowing toward its southern side. A few *Carex secta* plants are present along these channels.

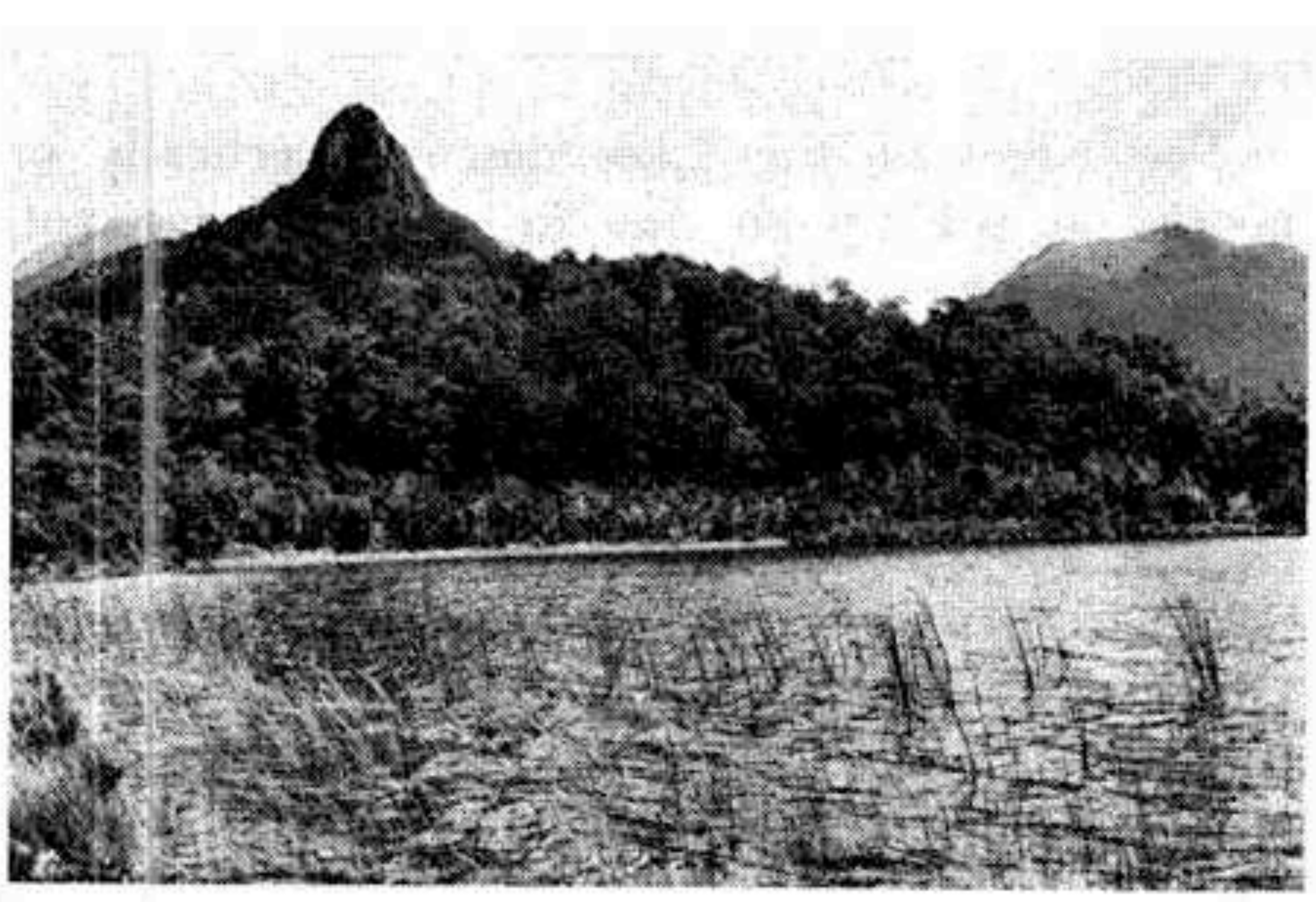

FIGURE 6. *Lake X with marginal* Eleocharis sphacelata (*right*) *and* Baumea rubiginosa (*left*).

FIGURE 7. *Levee at the margin of Lake X. The vegetation is dominated by* Leptospermum scoparium *bushes and tall* Baumea rubiginosa, Calorophus minor *and* Gleichenia dicarpa.

4. *Dome Mire*

This is a large mire resulting from the autogenic raising of the peat surface. The original site was a channel near the margin of the Te Anau glacier in late Otiran times. A melt-water stream or a shallow lake lay in the channel. Peat formation began after the ice receded and an examination of the peat showed that *Sphagnum* peat had been present almost from the inception of the site as a mire. The stratigraphy is recorded in Appendix I.

At present the mire has a gentle dome, roughly elliptical in shape, with a complex network of pools quasi-concentric around it (Fig. 8) and a larger pond to the north. Levels could not be taken across this mire because of its covering of *Leptospermum scoparium,* but the dome is nearly 3m higher than the margin on the southern side. Heights of water levels in adjacent pools vary by up to 60cm so that they often form a "staircase". The pool system is an interesting variant of the string-bog type (Sjörs 1961) and is the first of its particular form to be described from New Zealand.

The mire surface has a fairly close cover of clumps of *Leptospermum scoparium* up to 3m tall. Between these are clumps of *Dracophyllum oliveri* up to 1m tall, with *Calorophus minor* and other vascular plants, mosses and lichen species

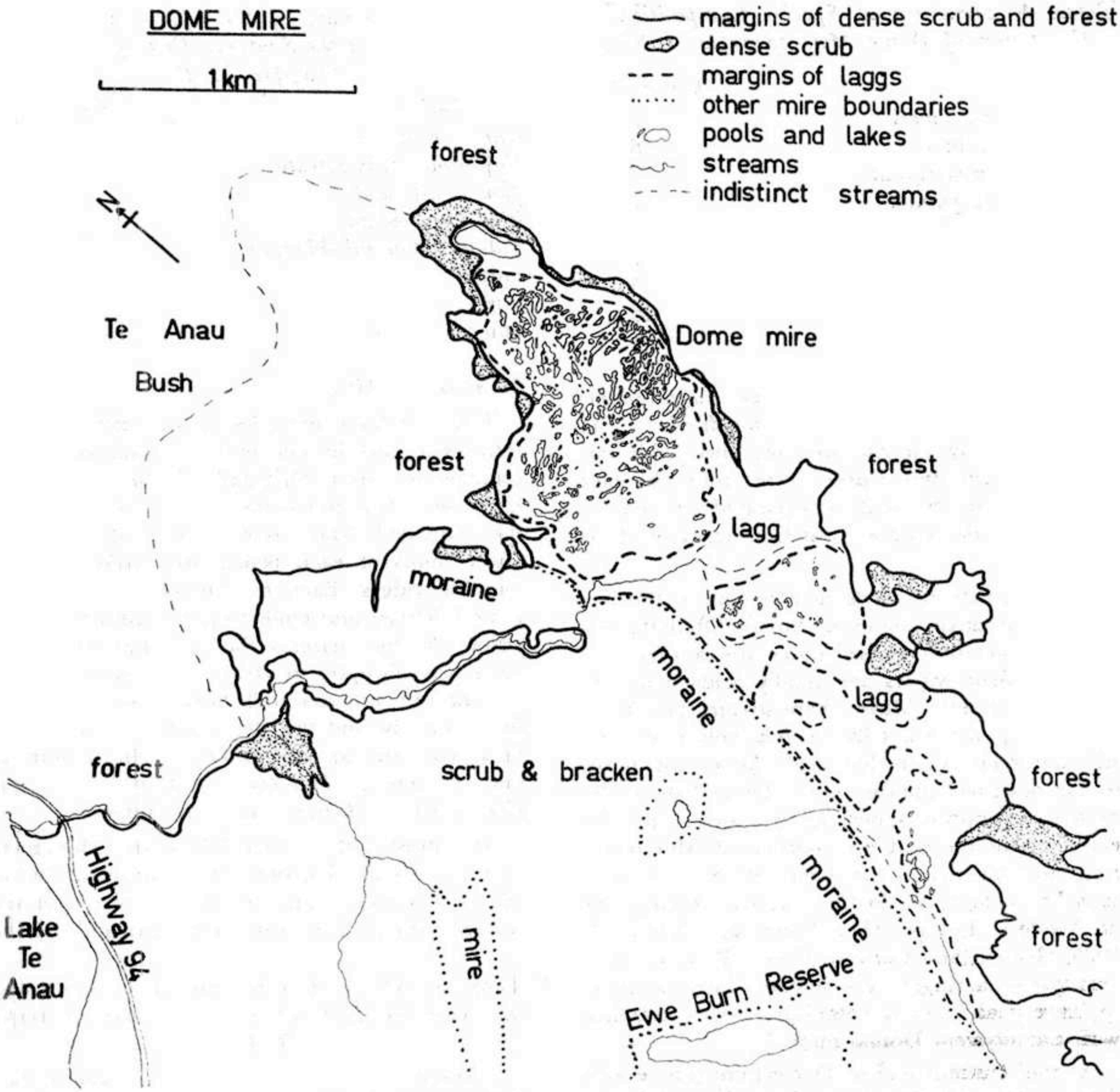

FIGURE 8. *Map of Dome mire and its environs.*

prominent on open ground (Table 4). The peat on the top part of the dome was rather dry during our visits (January 1970, 1971) but its flanks were wet.

A portion of the southern and western margin of the mire has been affected by fire and the surface disturbed by pig-rooting. Some of the unburnt parts of the margin have open vegetation with *Carex diandra, C. sinclairii* and *Sphagnum australe*, but usually there is a band of tall *Leptospermum* and *Dacrydium colensoi**, adjacent to forest dominated by *Nothofagus fusca* and *N.*

* The only known locality for this species east of the main divide in the South Island.

TABLE 4. *Summary of Species Composition of Vegetation of Dome Mire (Sample 70/53).*

Species	Cover (%)
Dracophyllum oliveri	32
Calorophus minor	16
Cyathodes empetrifolia	5
Pentachondra pumila	7
Cladia sullivanii	5
Sphagnum cristatum	7
Cladonia cf. *leptoclada*	5
litter	16
others	7

menziesii with emergent *Dacrydium cupressinum, Podocarpus spicatus* and *P. dacrydioides.* The mire drains, by sluggish streams, lined with tall *Leptospermum* and *Carex secta,* into channels flowing north-west and is separated by only a very low divide of raised peat from channels flowing south.

Mention may be made here of one of the important causative factors in broad differentiation of mire vegetation. Raised mires are rain-fed and therefore their waters are usually acidic and low in plant nutrients. Mires where streams flow from surrounding mineral soils are relatively more fertile and their waters less acid. All of the mires so far described appear to be dominated by the presence of nutrient-poor, acidic waters, with the exception of the southern margins of Monument mire and the margins of Dome mire. The latter thus has a lagg, as do the classical raised mires of Western Europe (Du Rietz and Nannfeldt 1925, Godwin and Conway 1939). This very fine example of a raised mire is one which we hope to have made into a botanical reserve, together with the adjacent Dismal mire.

At the southern end of Dome mire the vegetation of the old glacier-marginal channel is affected by water draining from higher ground. Its vegetation (Table 5) is composed predominantly of *Coprosma* cf. *intertexta* and *Carex secta* tussocks (*Cortaderia richardii* is physiognomically prominent) with a rich inter-tussock flora dominated by *Juncus articulatus.* There is periodic flooding of the area but it had dried out considerably in January, 1971.

TABLE 5. *Summary of the Species Composition of Vegetation at the Southern End of Dome Mire (Sample 71/2).*

Species	Cover (%)
Carex secta	11
Coprosma cf. *intertexta*	12
Juncus articulatus	11
Eleocharis acuta	5
Potamogeton suboblongus	5
mud	29
litter	9
others	18

5. *Amœboid Mire*

This is a large multi-lobed mire developed on terraces at two distinct levels and completely surrounded by forest. Originally the site appears to have been two fluvio-glacial benches formed as the extended Manapouri glacier shrank. The lower limits of each bench are marked by low moraine ridges. Each of the lobes of the mire is well defined and tends to have distinctive vegetation. At the margins the low mire vegetation gives way abruptly to *Dacrydium bidwillii, Phyllocladus alpinus,* and tall *Leptospermum scoparium* scrub. Behind this the forest contains *Nothofagus solandri* var. *cliffortioides* as the dominant, but numerous *Podocarpus dacrydioides* and *Elæocarpus hookerianus* trees are present.

A contrast with Richter's Rock and Monument mires is the physiognomic importance of *Dracophyllum oliveri.* The northern lobe contains a large tarn with a clear-cut margin and vertical

TABLE 6. *Species Composition of Vegetation of the Northern Lobe of Amœboid Mire (Sample 70/45).*

Species	Cover (%)
Calorophus minor	13
Dicranoloma billardieri	27
Oreobolus strictus	9
Sphagnum cristatum	13
Dacrydium bidwillii	8
Dacrydium laxifolium	5
Dracophyllum oliveri	8
litter	6
others	11

sides. The water level is just below the level of the mire surface. No boring was done but the peat appeared to be at least 5m deep. The vegetation of this area is represented in Table 6.

Shallow pools in its north-eastern corner contain hummocks of *Oreobolus pectinatus*. Between the upper and lower terrace levels a narrow neck of peat slopes down at about 5-8° through a break in the moraine ridge. This area is wetter than most of the vegetated surface. Water seeps through the area and the dominant vegetation cover consists of *Sphagnum australe* with some mounds of *S. cristatum, Dracophyllum oliveri, Calorophus minor* and moderately tall *Baumea rubiginosa* (Table 7, Fig. 9). Occasional *Carex secta* plants are present.

The north-western lobe is drier, with firmer peat than the rest of the mire, and shrubs up to 2m high are more common, especially *Phyllocladus alpinus, Dacrydium bidwillii* and *Dracophyllum oliveri*. The south-eastern lobe is wet and has a well-marked shallow pool system. A few of the pools carry stunted *Eleocharis sphacelata* and *Carex sinclairii* plants, as well as *Sphagnum falcatulum* and *Baumea rubiginosa*. Table 8 illustrates the predominant plant cover amongst the pools.

TABLE 7. *Species Composition of Vegetation Between the Upper and Lower Terraces of Amœboid Mire (Sample 70/48).*

Species	Cover (%)
Sphagnum australe	61
Sphagnum cristatum	18
Dracophyllum oliveri	8
Baumea rubiginosa	5
Calorophus minor	7
others	1

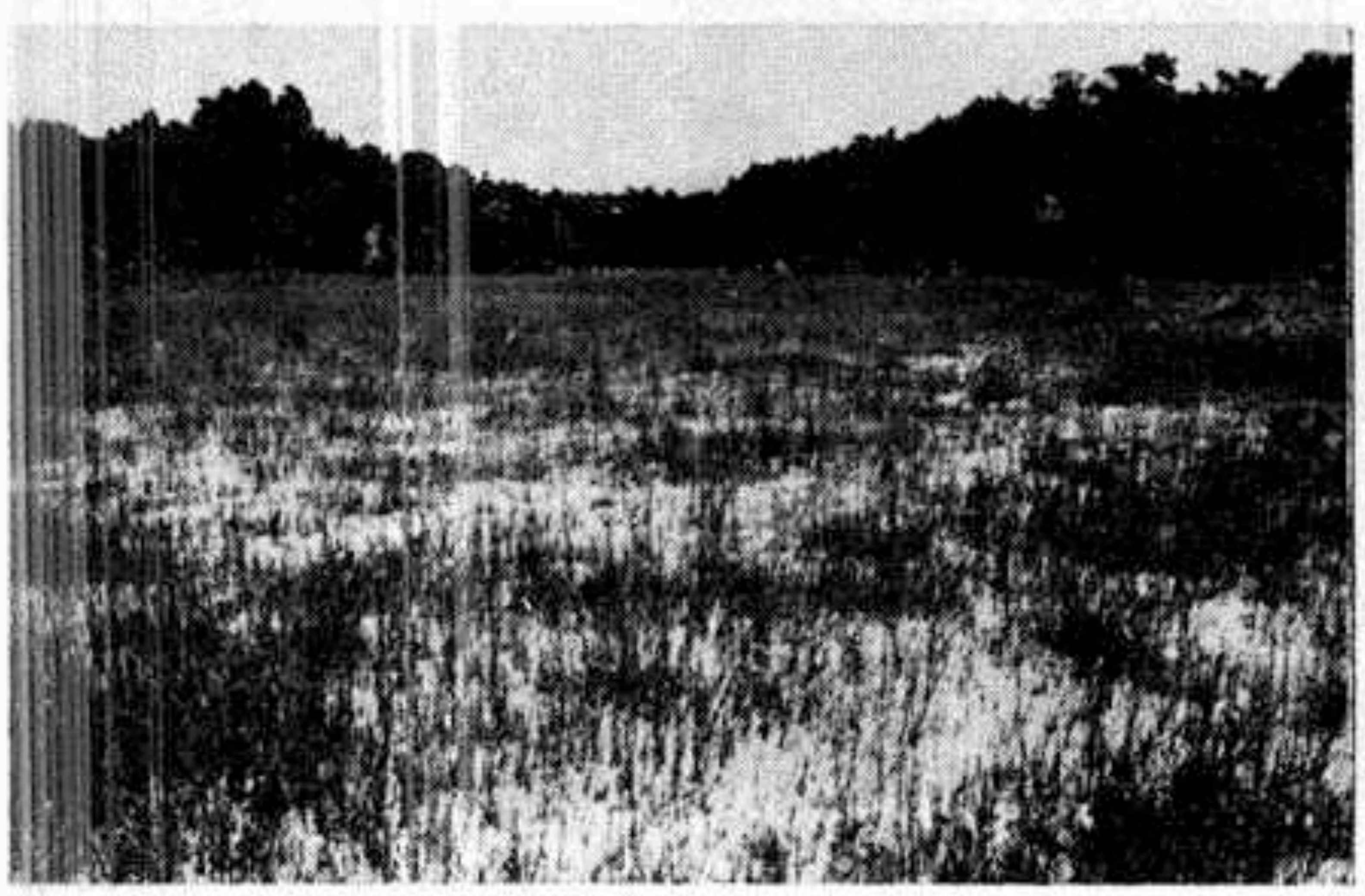

FIGURE 9. *Amœboid mire. A wet, sloping area with a dominant vegetation cover of* Sphagnum australe *and some* Baumea rubiginosa, Calorophus minor *and* Dracophyllum oliveri.

TABLE 8. *Species Composition of Plant Cover of Pools at the South-eastern Lobe of Amoeboid Mire (Sample 70/52).*

Species	Cover (%)
Calorophus minor	16
Sphagnum cristatum	19
Baumea tenax	5
Carex echinata	5
water	43
others	12

6. *Kepler Mire*

East of Lake Manapouri several large, old meltwater channels lie between moraine loops. The channels were occupied by the old Waiau river during the late Otiran glaciation as the extended Manapouri-Te Anau glaciers (virtually a piedmont ice-sheet in this area) lay in successively less advanced positions. These channels have become the sites of very large, elongated, raised mires including the Kepler mire. Towards the south it merges into the Freestone Hill mire, another of Cranwell and Von Post's study sites. The former forest around the mire has been destroyed by fire and the mire surface burnt, possibly many times. The most modified areas are almost solely covered by *Calorophus*, with *Sphagnum cristatum* on mounds and *S. falcatulum* in hollows. Less modified areas have a dense cover of *Dracophyllum oliveri* with various associate species including some *Leptospermum* (Fig. 10, Table 9). The margins carry lagg communities which are variable in composition. Stands of *Carex diandra* or *Juncus articulatus* are prominent (Table 10) and, near the raised margin, some stands of *Baumea rubiginosa* and *Sphagnum australe* occur. The latter forms cushions either beneath tall sedges and rushes, or along small, slow-flowing streams. The mire vegetation grades into *Leptospermum* scrub and grassland, which is rich in herbs and dwarf shrubs, both at the margins and on some "islands" of moraine which project above the wet area. Near a sluggish stream to the north-east there is an extensive area of sedge vegetation, presumably with comparatively nutrient-rich water. The predominant cover of this very wet lagg area is *Carex secta,* but between its tussocks are stands of turf-like vegetation in which other *Carex* species are present and on which *Marchantia berteroana* forms a felted mat. (Table 11). The whole surface quakes as one walks over it and the top metre or more consists of muck peat.

TABLE 9. *Species Composition of Little Modified Vegetation in Kepler Mire (Sample 70/31).*

Species	Cover (%)
Dracophyllum oliveri	23
Calorophus minor	11
Dacrydium bidwillii	6
Eucamptodon inflatus	5
litter	15
water	15
others	25

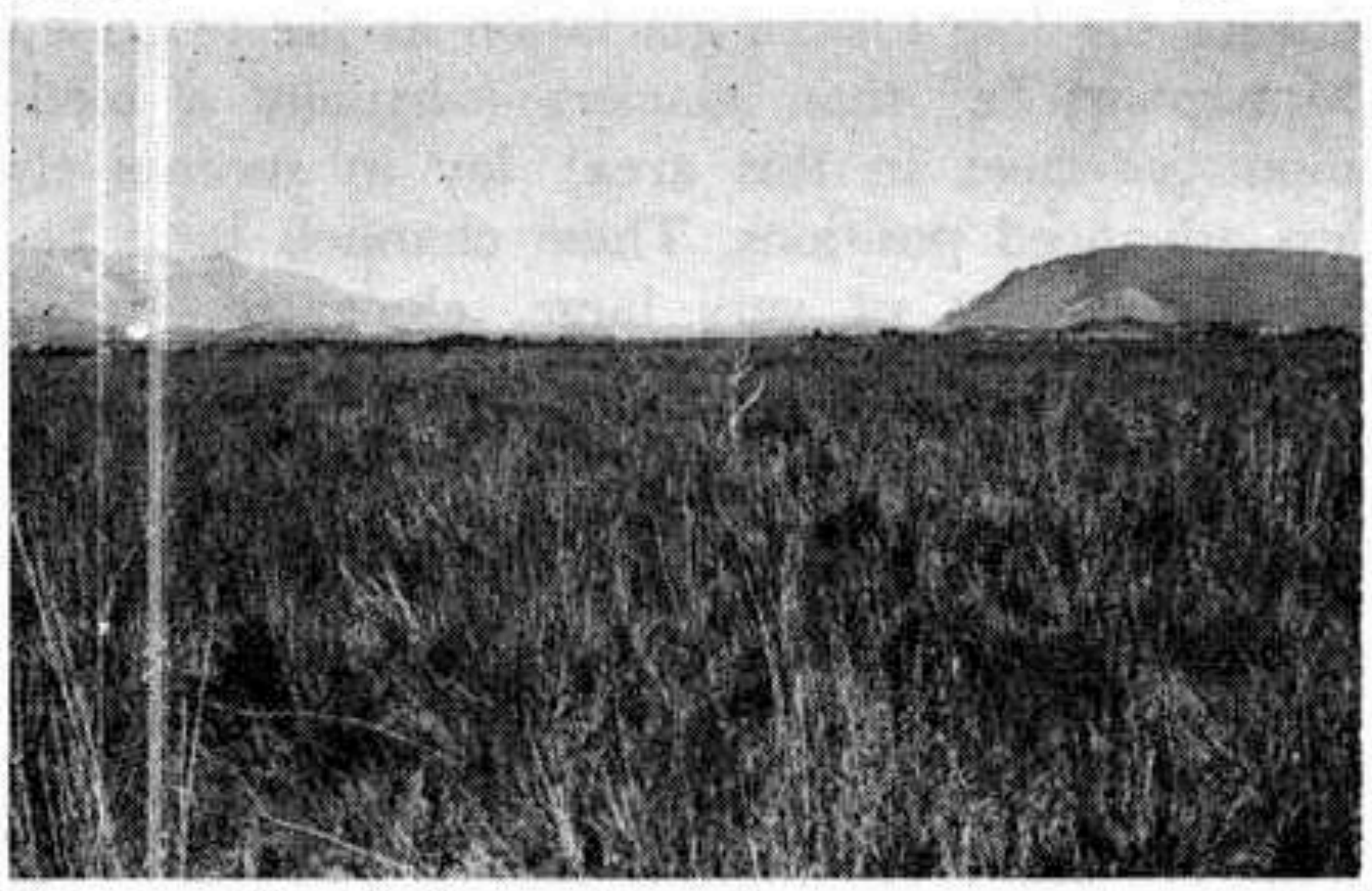

FIGURE 10. *Kepler mire. A large area dominated by* Dracophyllum oliveri, *with underlying* Calorophus minor.

TABLE 10. *Species Composition of Vegetation at the Margin of Kepler Mire (Sample 70/35).*

Species	Cover (%)
Carex diandra	46
Juncus articulatus	39
mud	11
others	4

TABLE 11. *Species Composition of Very Wet Lagg Community at the North-east Margin of Kepler Mire (Sample 70/39).*

Species	Cover (%)
Carex secta	23
Carex diandra	8
Carex maorica	9
Marchantia berteroana	32
Drepanocladus sp.	5
litter	11
others	12

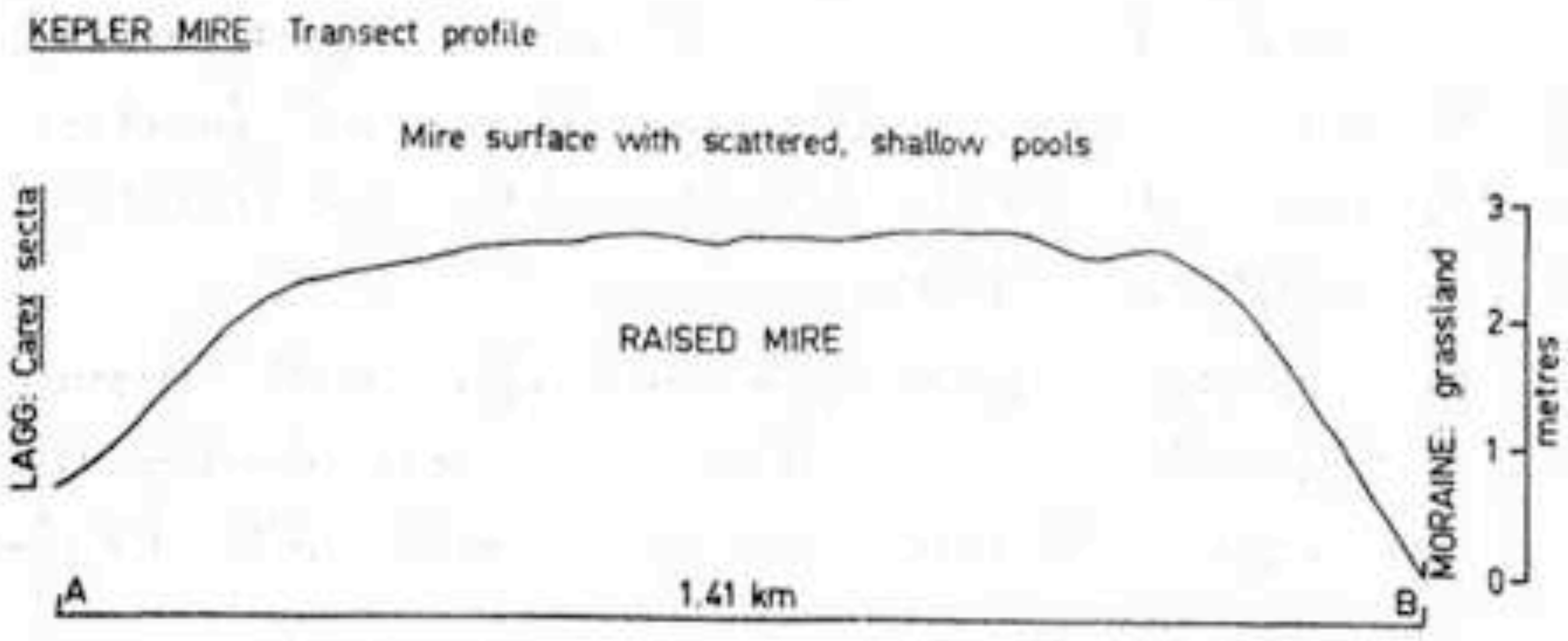

FIGURE 11. *Kepler mire. Profile along the line A-B, (Figure 13).*

FIGURE 12. *Kepler mire. Pool system with* Baumea rubiginosa *in the water and* Leptospermum scoparium, Dacrydium bidwillii, Dracophyllum oliveri *and* Calorophus minor *on the peat isthmuses.*

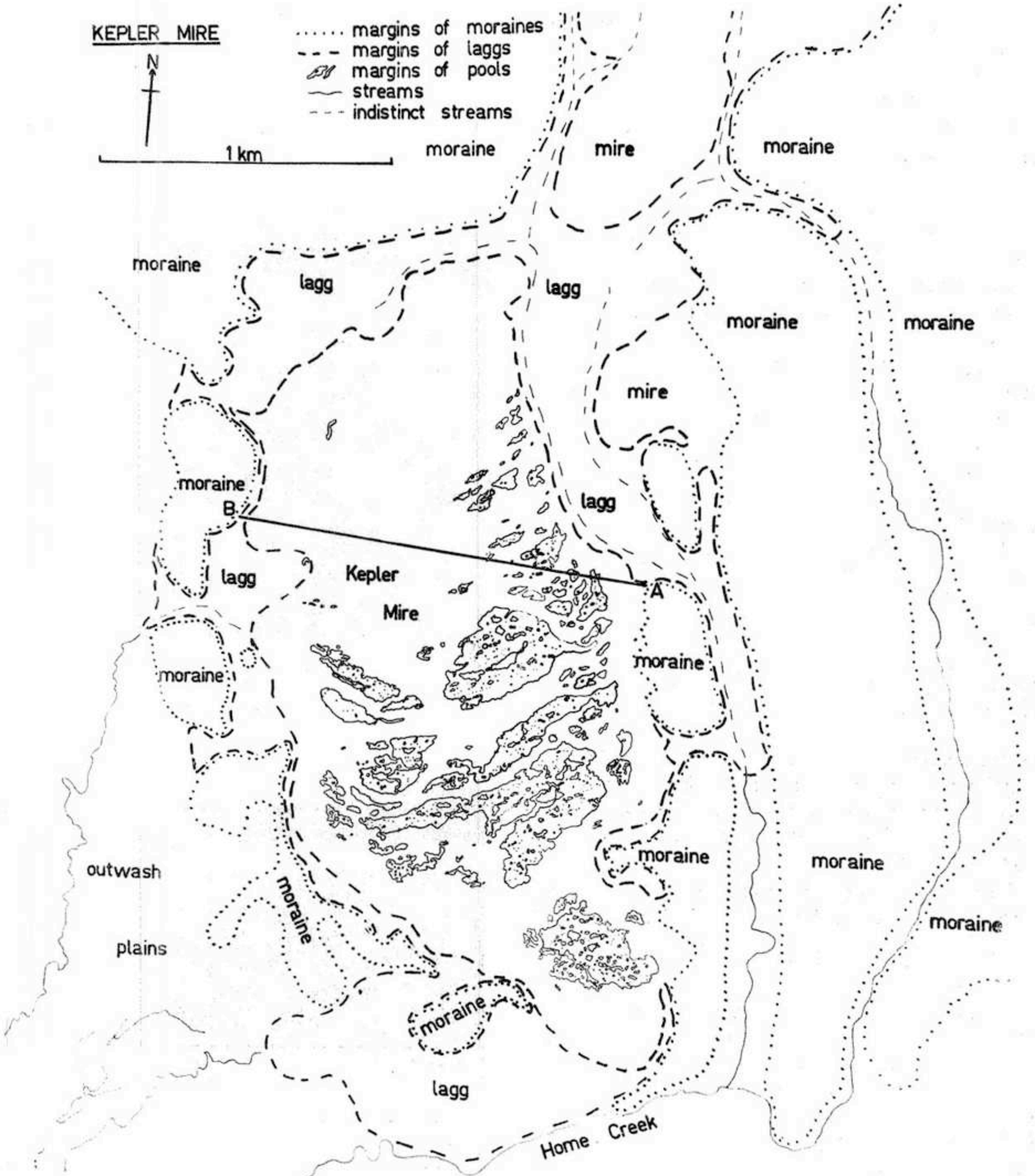

FIGURE 13. *Map of Kepler mire and its environs.*

Figure 11 shows the profile of the mire and there is a slope of about 2° or less from north to south. In the centre of the mire the stratigraphy is as shown in Appendix I.

One of the most striking features of the surface is a large and elaborate pool system of the string-bog type, developed on the highest part of the raised peat dome (Fig. 12). Many of the pools are narrow and elongated along the contours of the mire but in the main area of pools there is little systematic arrangement (Fig. 13).

Although pool systems of string bog form have been recorded elsewhere in New Zealand (Moar 1956, Burrows 1967, 1969), that on Kepler mire is easily the most extensive known here.

The pools are steep-sided and carry *Baumea rubiginosa, Sphagnum falcatulum, S. subsecundum* and algal mud. The complex of isthmuses and islands of vegetated peat between them have *Dracophyllum oliveri, Leptospermum scoparium* and other species, as well as a few plants of *Dacrydium bidwillii, D. intermedium* and *D. laxifolium*. These have probably escaped fire because of their isolated position.

In January of 1971, an exceptional drought year, the peat on the surface of the bog was fairly dry and many of the shallower pools had dried out leaving crusts of dried blue-green algæ and *Sphagnum falcatulum,* a species which is usually submerged or, at least, present in very wet places on the sides and floors of pools. These pools contained water at the same time the previous year.

The Kepler mire is another area which we hope to have retained as a botanical reserve.

7. *Lookout Mire*

This is a moderately large mixed mire (i.e. having diverse vegetation patterns). It lies in a former lake basin in the moraine formed during recession from the last main advance of the extended Te Anau glacier. At the western end the surface is raised and the vegetation dominated by *Calorophus,* with shallow pools containing *Sphagnum falcatulum*. The area has been burnt (probably many times), and the former forest surrounding the site completely destroyed. A cover of *Leptospermum* bushes has been almost completely destroyed, only charred sticks remaining. Dense *Leptospermum* stands and some grassland are present on the surrounding dry land.

FIGURE 14. *Lookout mire. Stand of* Lepidosperma australe *and* Baumea tenax *with scattered small* Phormium tenax.

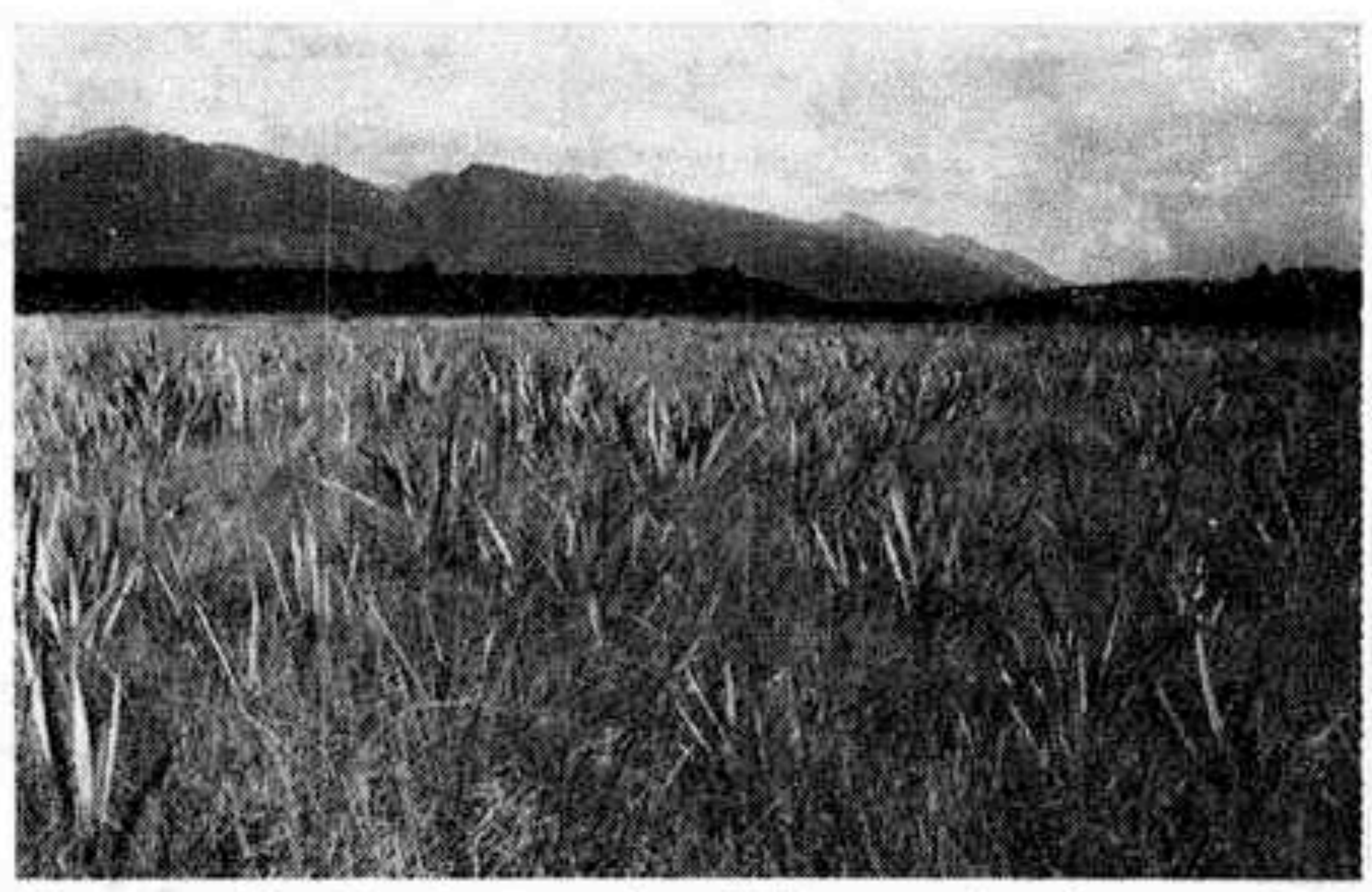

FIGURE 15. *Lookout mire. The predominant plant cover consists of* Carex diandra, C. sinclairii, Juncus articulatus *and small* Phormium tenax.

Toward the eastern end there are several bands of vegetation, changing from *Calorophus*-dominated to an area dominated by mosaics of *Baumea* *tenax, Lepidosperma australe,* and *B. rubiginosa* (Fig. 14, Table 12). Finally, there are areas with *Carex echinata, C. diandra, C. sinclairii, Coprosma* cf. *intertexta,* stunted *Phormium tenax* and other species (Table 12, Fig. 15). Water from a small stream flows into this end of the mire, which is very wet. The depth of peat in this mire was not measured.

TABLE 12. *Variations in Species Composition of Vegetation Toward the Eastern End of Lookout Mire.*

Sample 71/18	Cover (%)
Baumea tenax	31
mud	29
litter	32
others	8
Sample 71/10	
Lepidosperma australe	20
Baumea tenax	5
Carex sinclairii	6
mud	8
litter	52
others	9
Sample 71/17	
Baumea rubiginosa	20
Baumea tenax	15
Lepidosperma australe	6
litter	55
others	4
Sample 71/20	
Carex sinclairii	12
Carex diandra	5
Phormium tenax	7
Juncus articulatus	9
Coprosma cf. *intertexta*	6
Blechnum "procerum"	12
litter	41
others	8

8. *Oioi Mire*

In the middle reaches of the Garnock Burn this large mire is in a former, shallow lake basin dammed by flood-plain levees. It is horizontal and the organic sediments are at least 220cm deep but the sediments were not examined in detail. Apart from the margins, where dense *Leptospermum* merges into forest dominated by *Nothofagus solandri* var. *cliffortioides* (with scattered *Podocarpus dacrydioides* emergent) it is covered by a close vegetation of *Leptocarpus similis* and is very wet.

TABLE 13. *Species Composition of the Vegetation of Oioi Mire (Sample 71/37).*

Species	Cover (%)
Leptocarpus similis	28
Carex sinclairii	5
litter	57
others	10

It is surprising to find such a plant community in an inland station. *Leptocarpus* is known to occur in various places inland (Edgar 1969), usually forming a narrow band round lakes. It is occasionally present in peat mires, for example, in isolated clumps in mires near the Arawhata and Haast rivers in South Westland and in Dismal mire near Te Anau. Round Lake Manapouri's eastern end it forms a conspicuous band at the water's edge. Otherwise extensive areas of the plant are known only from coastal localities and the Garnock Burn site is of considerable interest. There may be an involvement with water draining from an area of calcareous rocks.

9. *Lake Z Mire*

Near lakes X and Y is a third lake, Z, which forms part of the same complex of wetlands. It is almost completely surrounded by tall, dense *Leptospermum* 5-6m tall. It has a marginal belt of *Carex secta, Eleocharis sphacelata* and *Phormium tenax* but this rapidly gives way to the *Leptospermum* stand. There is a closed canopy in many places but many of the shallow-rooted trees are wind-thrown. Beneath the canopy, *Carex secta* and various shrubs and plants characteristic of relatively nutrient-rich sites are present (Table 14), but in places the *Carex* has recently died. Young *Nothofagus s.* var. *cliffortioides* and some *Podocarpus dacrydioides* trees are present, usually rooted on dry sites such as old *Carex* stumps.

There is probably a succession toward forest, perhaps because the locality is drying out. The maximum depth of organic sediments measured was 350cm but the stratigraphy was not examined. The vegetation structure may be gauged from Figure 16, transect data (Appendix II) and the results of point analysis of the shorter plant cover (Table 14).

TABLE 14. *Species Composition of the Vegetation of Lake Z Mire (Sample 70/6).*

Species	Cover (%)
Carex dissita	10
Carex secta	10
Potamogeton suboblongus	17
Sphagnum australe	18
mud	23
others	22

FIGURE 16. *Lake Z Mire. A dense-canopied stand of* Leptospermum scoparium *overlies a thick mat of* Sphagnum australe. *Dead* Carex secta *stumps are evident.*

Similar vegetation is very extensive in the Garnock Burn area, probably amounting to at least 200ha. The margins of many of the other mires which are surrounded by forest also have similar vegetation, a form of lagg community, with relatively nutrient-rich conditions.

10. *Kakapo Mire*

This mire, which has a minimal accumulation of organic sediment, lies on a slow-flowing stream with considerable stretches of open water (Fig. 17). The stream drains an old outwash channel

FIGURE 17. *Kakapo mire. Tall* Phormium tenax *and* Carex secta *occupy the middle ground, while* Juncus gregiflorus *is important in the foreground.*

of the extended Te Anau glacier and its water is derived from springs. The water level has been artificially raised about 0.5m but this has probably had little effect on the main part of the mire. It has, however, begun to kill an area of *Calorophus* and *Dacrydium bidwillii* on acid peat at the eastern end, presumably by causing an influx of nutrient-rich water. Luxuriant *Phormium tenax, Carex secta* and *Nasturtium aquaticum* are the predominant plants in water up to at least 2m deep. *Juncus articulatus, J. gregiflorus, Carex maorica* and *C. coriacea* are common at its margins and *Lemna minor* floats on the water.

11. *Stream at Shallow Bay*

At Shallow Bay, Lake Manapouri, in an abandoned channel of the Waiau river, a spring-fed stream has a marginal mire. A steep scrub-covered bank overlies each side of the stream and heavy forest surrounds the site. There is no true peat development, although organic muck is present between the tussocks of the dominant *Carex secta* and *Juncus gregiflorus* plants (Table 15). There seems to be a fairly rapid decay of organic sediment. The maximum depth of water is 1m and the bottom sediments are sands.

TABLE 15. *Species Composition of Vegetation of Stream at Shallow Bay (Sample 70/57).*

Species	Cover (%)
Azolla rubra	16
Lemna minor	5
Juncus gregiflorus	13
Carex secta	13
Carex maorica	9
Callitriche stagnalis	8
Eleocharis acuta	5
litter	13
water	5
others	13

POOLS OF THE ACIDIC MIRES

Many of the mires studied had areas of open water. These are particularly well developed on the acidic mires where they may range from small depressions in the peat or pools varying in depth from a few centimetres to a metre or more (including the elongated string-bog pools) to large, gloomy ponds and lakes up to 5m or more deep. The pools of the string-bog complexes have a bottom of very sloppy peat and algal mud which obscures their true depth.

Although some are devoid of macro-vegetation there is partial colonization of many pools by sedges and other plants. Shallow pools on some raised mires have, apart from a sparse cover of *Baumea rubiginosa* and the tiny *Utricularia monanthos,* colonizing clumps of *Oreobolus pectinatus* and *Centrolepis ciliata,* as well as *Drosera binata* (Fig. 18). Deeper pools may be colonized by *Sphagnum falcatulum, S. subsecundum, Baumea rubiginosa,* and, rarely, *Eleocharis sphacelata.* However, none of this colonization is rapid and little, if any, peat accumulation results from the presence of these species. *Baumea* and *Eleocharis* in the acid mire pools are usually stunted and are presumably suffering from nutrient deficiency. The poor performance of *Sphagnum* species is less easy to explain and it may be that the two pool-inhibiting species have low rates of growth. Certainly colonization of the acidic mire pools by *Sphagnum* in the Manapouri-Te Anau region, and in other areas of New Zealand, seems very reduced compared with sites in Britain, where the colonising species are usually *Sphagnum subsecundum* and *S. cuspidatum* (closely related to *S. falcatulum*). An alternative explanation for the poor performance of aquatic Sphagna has been given by Boatman and Armstrong (1968), who suggest that there may be competition from algae.

FIGURE 18. *Amœboid mire. Shallow pool inhabited by sparse* Baumea rubiginosa *and mounds of* Oreobolus pectinatus *and* Centrolepis ciliata.

Poor colonization results in these acid mire pools having well-defined, steep margins. Apparently peat accumulation is continuing under the mire vegetation but is virtually non-existent in the pools, resulting in increasing pool depth as the mire ages. Six lakes were also investigated. Three of these, lakes X, Y and Z, occur near the Hope Arm of Lake Manapouri, the fourth is at the northern end of Dome mire, and the others are in the Eweburn reserve (Fig. 1) Like the pools they have steep margins where there is an abrupt change from mire vegetation to open water. They generally possess a marginal, often discontinuous, band of *Baumea rubiginosa* and *Eleocharis sphacelata* with some *Phormium tenax* and *Carex secta*. Although the plants are tall and apparently not suffering from nutrient deficiency, colonisation of the lakes is negligible, and indeed the lakes may even be expanding slightly at the expense of the mire. There is evidence that under the weight of the *Phormium* plants the peat at the margins is unstable and from time to time pieces break off and sink. The lake depths at the margins are roughly equivalent to the depths of the peat in adjacent parts of the mires. All this suggests that the lakes have been of roughly the same dimensions since major peat accumulation began. As the mire peat has grown upwards their surface levels have been raised.

The occurrence of string-bog pool systems in New Zealand has been briefly reported by Moar (1956) and Burrows (1967, 1969). Otherwise they are known to be developed extensively only in the Boreal peat-lands of Scandinavia, Russia and Northern Canada (Sjörs 1961) and on a smaller scale in Britain and Germany (Ratcliffe and Walker 1958, Boatman and Armstrong 1968, Troll 1954). The causes of their formation are by no means well known but, as they occur in New Zealand, it is unlikely that there is an obligatory connection with the presence of permanently frozen ground, as has been suggested elsewhere (Schenk 1970). Ice-thrusting when the pools freeze in winter may be involved, though the causal factors may be more complex (Boatman and Armstrong 1968). A series of careful experiments and observations is required before further conclusion can be drawn.

CONSERVATION

There are two distinct conservation problems. The first concerns the plan by the New Zealand Electricity Department to raise Lake Manapouri. The second concerns the modification or destruction of wetlands during farm development by the Department of Lands and Survey, assisted by the Southland Catchment Board.

1. *Lake Manapouri Wetlands*

If Lake Manapouri is raised by as much as 8m, about 400ha of wetlands will be destroyed. This will include nearly all the wetlands near the Monument and in the middle and lower Garnock Burn. Access to the wetlands of the upper Garnock Burn will become difficult, if not impossible. Clearance of scrub from such large areas of peat-land to facilitate access would be a very difficult and costly process.

The Garnock Burn and Monument wetlands are important scientifically and because of their location within the Fiordland National Park. No other such extensive areas of wetland vegetation are known in the Park, and, unlike many of those outside it, the mires are little modified. Although traversed by deer trails they are unattractive to deer because the plants are unpalatable. Relatively minor damage has been caused by trampling. They have an important use for comparison with more modified wetland vegetation.

Some of the mires are unique vegetationally and some preserve fine examples of particular kinds of vegetation which are scarce outside the National Park. They are sites of occurrence for some uncommon plants (especially *Eleocharis sphacelata, Liparophyllum gunnii* and *Carex capillacea*) and animals (especially crested grebe and fernbirds).

For these reasons we are recommending to the various interested parties that Lake Manapouri should be raised by no more than about 2.5m.

2. *Other Wetlands of the Te Anau Basin*

The main hindrance to the conservation of wetlands outside the Fiordland National Park is the low esteem in which they are held by laymen and persons engaged in land management. Already large areas of wetland in the Te Anau Basin have been modified or destroyed by fire, top-dressing, drainage or flooding. There are good reasons for attempting to alter some such areas for the benefit of land development. There are also good reasons for wishing to preserve other areas of peat-land relatively undisturbed. The most cogent of these is their importance in maintaining a steady flow of water. They soak up water during heavy storms and release it gradually, thus preventing erosion and flooding and, during droughts, permit a reliable water supply. This was strongly evident during the serious drought of the summer of 1970-71. It may be that the peat areas will become important in future as filters of the nutrients from the run-off from farmland, thus preventing eutrophication of streams and lakes. The draining of all peat areas is therefore by no means a good hydrological practice.

Otherwise the preservation of the wetlands is desirable for the sake of their scientifically important and interesting fossil content (in the form of peat, macrofossils, pollen and spores), vegetation and morphology. The two areas which we are recommending for reservation are Dome mire—Dismal mire and the very large Kepler mire. Very little physical work is required to ensure that these are maintained in their present state. If the two areas are reserved without further modification, vegetation types representative of many of those of the Te Anau Basin will be protected, as will their very interesting hydrological systems. If there was no other good reason, the occurrence of *Dacrydium colensoi* at Dome mire and *D. intermedium* at Kepler mire would warrant the protection of these two areas. Although it is intended to drain the margins of the Kepler mire, the portion of particular botanical interest can be reserved without much difficulty.

MISCELLANEOUS NOTES

Names for the various mire systems are informal. As far as possible they are related to adjacent place names but some were coined because of the lack of names for features nearby.

The authorities for plant names are those listed in H. H. Allan, 1961: Flora of New Zealand, Vol. I, Govt. Printer, Wellington. (indigenous dicotyledonous angiosperms, ferns, gymnosperms) (with the exception of *Pteridium esculentum* (Forst.) Diels and *Pseudopanax colensoi* (Hook.f) Philipson); L. B. Moore & E. Edgar 1970: Flora of New Zealand, Vol. II, Govt. Printer, Wellington (indigenous monocotyledonous angiosperms); A. R. Clapham, T. G. Tutin & E. F. Warburg, 1962: Flora of the British Isles, 2nd edn., Cambridge University Press (introduced plants); G. O. Sainsbury 1955: A Handbook of the New Zealand Mosses, Royal Society of New Zealand, Dunedin (mosses).

Aerial photographs for the area of study are: 1839A/15,16; 2522/3,4,5; 2524/1,2,3.

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APPENDIX I

STRATIGRAPHIC DESCRIPTIONS

1. *Richters Rock Mire*

Depth (cm)

Top 0-10 dark yellowish-brown, fibrous moss peat, many plant roots.

10-70 dark reddish-brown, fibrous peat, many plant roots.

70-285 dark reddish-brown, soft, well humified peat. Wood at 70-100, 120, 180-210, 260-300cm (mostly small pieces but some logs). Becoming firmer from 130cm and gritty with fine sand from 210cm.

285-450 Very dark grey moderately firm peat, moderately humified, containing fine sand to 330 cm and wood at 350, 390, 420, 440-450cm.

450-540 dark reddish-brown moderately firm peat with a blackish band at 460-472cm and wood throughout. Softer at 495-540cm.

540-570 dark brown silt and sand with some organic matter.

570-572 dark greyish-brown sand and pebbles.

572-645 greenish-grey, dense, plastic clayey silt. Pebbles at 650cm.

645-650 grey sand.

2. *Monument Mire*

Depth (cm)

Top 0-130 not examined closely; consisted of fibrous peat with many plant roots.

130-390 reddish-brown fibrous moss peat, soft, wet. *Dracophyllum* rootlets 150-200cm, *Elaeocarpus* seed 350cm, *Baumea* seed 325cm, *Eleocharis* seed 390cm.

390-450 grey silt with fibrous organic fraction, becoming less organic in lower 50cm.

450-500 grey silt with lenses of sand at 465-70, 485-90cm.

500-695 grey silt with an organic fraction.

695-785 blue clay.

3. *Dome Mire*

Depth (cm)

Top 0-150 brown to red-brown fibrous peat with rootlets of *Calorophus, Dracophyllum.*

150-200 red brown peat with very fine fibrous material and small pieces of wood; wood at 200cm.

200-475 dark-brown coarse fibrous peat with wood fragments throughout.

475-500 red brown fibrous, well humified peat.

500-540 gravel, silt layer at 537cm.

4. *Kepler Mire*

Depth (cm)

Top 0-30 dark reddish-brown, firm, fibrous, moderately humified peat, oxidizes darker. Many roots.

30-230 dark reddish-brown soft, fibrous, moderately humified peat; becoming slightly firmer with depth. *Spagnum* noticeable 30-210cm. Wood at 110, 200-230cm.

230-310 dark reddish-brown moderately soft moderately humified peat. Firmer from 260cm and becomes less fibrous and more amorphous. Wood at 260, 290cm.

310-388 dark reddish-brown, coarse-grained woody peat, becoming firm.

388-488 dark reddish-brown very firm dry peat. Wood uncommon.

488-491 dark yellowish-brown firm moss peat.

491-492 dark reddish-brown, firm, sandy moss peat.

492-494 dark greyish-brown sandy peat.

494- greenish-grey sand.

APPENDIX II

SUMMARIES OF TRANSECTS

1. *Richters Rock Mire*

Transect I/2

SPECIES	NUMBERS OF PLANTS Height Class <60cm	60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m	Hgt (m)	Diam (cm)
Dacrydium cupressinum	—	—	—	—	1	21	60
Podocarpus ferrugineus	3s†	—	—	—	—		
Nothofagus s. var. *cliffortioides*	∞s	1	1,2d†	2	4,1d	9-15	15-30
Elaeocarpus hookerianus	4	6	—	—	2	6,12	20
Phyllocladus alpinus	5	∞	21	1	1	12	15
Leptospermum scoparium	6	3	1,2d	—	16,1d	9-12	5-16
Cyathodes juniperinum	3	10	6	—	—		
Dacrydium bidwillii	—	3	—	—	—		
Dracophyllum longifolium	1	—	1	—	—		
Myrsine divaricata	3	3	1	—	—		
Neomyrtus pedunculata	∞s	1	23	—	—		
Elytranthe flavida	parasite	—	—	—	—		
Rubus australis	scrambler	—	—	—	—		
Bryophytes of the forest	∞	—	—	—	—		

Transect I/3

SPECIES	NUMBERS OF PLANTS Height class <60cm	60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m
Nothofagus s. var. *cliffortioides*	1	—	—	1d	—
Elaeocarpus hookerianus	—	—	—	—	—
Phyllocladus alpinus	2	2	1d	—	—
Leptospermum scoparium	∞	∞	4,1d	6	—
Cyathodes juniperinum	—	1	—	—	—
Dacrydium bidwillii	1	—	—	—	—
Dracophyllum longifolium	20s	11	—	—	—
Myrsine divaricata	5s	—	—	—	—
Lichens, mosses, liverworts, ferns and angiosperms of the open mire.	∞				

Transect I/4

SPECIES	NUMBERS OF PLANTS				
	Height class <60cm	60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m
Phyllocladus alpinus	3	2	1	—	—
Leptospermum scoparium	∞	15	8,25d	—	—
Dacrydium bidwillii	2	15	—	—	—
Dracophyllum longifolium	1	3	—	—	—
Lichens, mosses, liverworts, ferns and angiosperms of the open mire.	∞				

* The information tabulated results from counts of plants in three consecutive transects 20m long x 3m wide, extending from forest on dry ground across the mire margin and out onto the mire proper.

2. *Monument Mire* (Margin)

Transect III/8

SPECIES	NUMBERS OF PLANTS						
	Height Class <60cm	60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m	Hgt (m)	Diam (cm)
Dacrydium cupressinum	—	—	—	—	1	18	25
Podocarpus dacrydioides	2s	—	—	—	1	17	25
Nothofagus solandri var. *cliffortioides*	∞s	—	—	4	6	7-18	5-25
Elaeocarpus hookerianus	—	—	—	—	3	7-9	5-15
Phyllocladus alpinus	12	—	—	1	—		
Leptospermum scoparium	2	—	—	—	1	10	10
Cyathodes juniperinum	1	—	—	—	—		
Myrsine divaricata	∞s	3	—	1	—		
Neomyrtus pedunculata	15	23	25	2	—		
Coprosma "parviflora"	—	1	—	—	—		
C. propinqua	1	2	—	—	—		
Pseudopanax colensoi	—	—	—	—	—		
Gaultheria antipoda	—	—	—	—	—		
Rubus australis	1s	—	—	—	—		
Lichens, mosses, liverworts, ferns etc. of the forest	∞						

Transect III/9

SPECIES	NUMBERS OF PLANTS						
	Height Class <60cm	60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m	Hgt (m)	Diam (cm)
Dacrydium cupressinum	1s	—	—	—	—		
Podocarpus dacrydioides	1s	—	—	—	—		
Elaeocarpus hookerianus	1s	—	—	—	1	9	15
Phyllocladus alpinus	—	1	1	—	—		
Leptospermum scoparium	∞s	4	56,7d	42,1d	6	6.7	2.5-10
Cyathodes juniperinum	1s	—	—	—	—		
Myrsine divaricata	∞s	5	5	1	—		
Neomyrtus pedunculata	—	4	—	—	—		
Coprosma "parviflora"	∞	2	—	—	—		
Pseudopanax colensoi	1s	—	—	—	—		
Gaultheria antipoda	—	1	—	—	—		
Lichens, mosses, liverworts, ferns etc. of the forest	∞	∞					
Sedges, rushes and other herbaceous plants	∞	∞					

3. *Monument Mire* (Open Mire)

Transect III/7

SPECIES	NUMBERS OF PLANTS				
	Height class <60cm	60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m
Leptospermum scoparium	—	8	6,1d	13,4	—
Dacrydium bidwillii	1	2	3	—	—
Lichens, mosses, etc. of open mire	∞				

4. *Lake Z Mire*

Transect II/3

SPECIES	Height Class <60cm	NUMBERS OF PLANTS 60cm-1.5m	1.5-3.0m	3.0-6.0m	>6.0m	Hgt(m)	Diam (cm)
Nothofagus s. var. *cliffortioides*	1	—	—	—	—		
Leptospermum scoparium	∞	—	2	—	49,14d	6.0-7.0	5.0-10.0
Coprosma "parviflora"	13	—	—	—	—		
C. propinqua	3	—	—	—	—		
C. rugosa	3	—	—	—	—		
Myrsine divaricata	3	1	5	—	—		
Pseudopanax crassifolium	∞	—	—	—	—		
Carex secta	—	6,2d	—	—	—		
Mosses, ferns	∞						
Small angiospermous herbs	∞						

†s—seedlings.
d—dead.