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SPHAGNUM MOSS IN OTAGO

A discussion report

by

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SPHAGNUM MOSS IN OTAGO

A DISCUSSION REPORT

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SUMMARY AND CONCLUSIONS

1. Onset of Sphagnum harvesting in Otago upland bogs is of concern because of the lack of assessment of sustainability of the resource, no knowledge of growth rates, and the lack of secured representative natural areas.

2. Three species of Sphagnum are important cushion-and peat forming plants in these Otago ranges. The commonest, *S. cristatum*, occurs in many different situations, associated with wire rush at lower altitudes, red tussock and various sedges higher up, and with cushion plants at high altitudes.

3. Sphagnum and cushion wetlands are a dominant habitat feature of the rain-catching ranges which separate the southern plains from Central Otago. Available data on wetlands in 8 Ecological Districts is summarised. Waipori Ecological District in particular is characterised by this vegetation and is in urgent need of overall biological survey.

4. Sphagnum growth can occur in sequential cycles, alternating with cushion plants, depending on changing patterns of water movement through a wetland.

5. Research needs are outlined for monitoring of Sphagnum harvest sites, measurement of growth rates and cycles in Sphagnum communities, survey to assess conservation requirements, and understanding the hydrological importance of upland wetlands.

6. Because Sphagnum harvesting creates a new threat to biological conservation there is an urgent need to implement existing proposals for reserves and protected natural areas, and for PNA survey of the Waipori and Manorburn Ecological Districts.

INTRODUCTION

Harvesting of Sphagnum moss for export has recently been initiated in Otago and Southland. Within Otago, Sphagnum picking has been concentrated in the uplands which broadly flank the Lammerlaw and Lammermoor Ranges, mainly on pastoral lease land but apparently also from within reserves. It is of considerable concern that

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* text as received from Botany Division, DSIR.

this harvesting is being carried out without cognisance of the biological and hydrological importance of Sphagnum wetlands, and without the information necessary to ensure the resource is managed for sustainable yield.

This report has been prepared for Department of Conservation, Southern Region. It summarises what is known about the biology of Sphagnum communities in Otago, highlights their botanical and other values, comments on their management and conservation, and outlines the research necessary to assess their possible sustainable utilization.

SPHAGNUM MOSS

Among mosses, Sphagnum is unusual in several respects. Because many of the leaf and stem cells are large and empty, with pore-like openings, Sphagnum has remarkable capacity to absorb and retain water, hence its usefulness in horticultural potting mixes, whether as picked fresh stems, or as partly decomposed fragments in peat. Sphagnum is a major peat-forming plant of bogs in temperate zones of both northern and southern hemispheres. Accumulation of peat is facilitated by permanent wetness, high acidity, and low oxygen levels.

New Zealand has 5 or 6 species of Sphagnum, which vary in abundance, in their growth forms and water-holding capacity and hence their ecological roles in wetlands.

Three species are important peat-formers in Otago (Fig. 1):

Sphagnum cristatum

much the commonest species, and one having a wide ecological tolerance, forming sopping wet, soft but dense cushions or extensive carpets. This species is the one which most Sphagnum pickers will concentrate on. Its water-holding capacity exceeds that of other species, so its stem tips and hummocky cushions can reach 10 or so cm above the level of the water table. Colour ranges from pale green (in partial shade) to yellow, bronze or reddish.

Sphagnum falcatulum

widespread but less abundant than *S. cristatum*, this is a more wispy species, pale or dark green, with less dense foliage, and lesser holding capacity. It is usually found submerged in bog pools, or as a low emergent at pool or stream margins, and when it does form cushions, they are less dense than *S. cristatum* and tend to dry out to a white colour on their crests.

Sphagnum squarrosum

forms bright green low cushions in slightly wetter flushed ground than S. cristatum, but the two can occur together. S. squarrosum, known also from the northern hemisphere, was until recently recorded in New Zealand only from the Great Moss Swamp, but is now known to extend west at least to the Garvie Mts.

SPHAGNUM VEGETATION AND HABITATS

Taking a New Zealand-wide view of wetland types, the role of Sphagnum is illustrated by a diagram from Andrew Dobson's paper on mire types in New Zealand (Fig. 2). Sphagnum is important in oligotrophic (ie. very low fertility) soils, mainly in cool climates, but it extends also into flush conditions where inflowing water carries nutrients and dissolved oxygen at greater concentrations than those found in wholly rain-fed bogs. *S. cristatum* occurs through most of New Zealand but becomes an increasingly important bog component in upland sites, and in lowland ones in the west and south of the South Island.

The relatively wide ecological range of S. cristatum is illustrated by its roles in different wetland types in Otago and Southland, summarised as follows:

1. Lowland bogs have *Sphagnum cristatum* patches associated with dense mats of wire rush (*Empodisma minus*), tangle fern (*Gleichenia dicarpa*), and often scattered shrubs of manuka and dracophyllum. This vegetation typifies many of the basin and blanket bogs of the Southland Plains, the crests of low ranges such as Ajax Bog in S.E. Otago and extends into eastern Otago at least at the small Black Swamp near Milburn.

2. Montane (and lowland) red tussock (*Chionochloa rubra*) grassland grows on wet mineral soils as well as peat, and will often be associated with *Sphagnum cristatum*, *Carex coriacea*, *Carpha alpina*, and *Schoenus pauciflorus* in valleys, gulleys and depressions, especially on the flanks of the wet Otago ranges.

3. At high altitudes *Sphagnum cristatum* forms mosaics with cushion plants, especially *Oreobolus pectinatus* and *Donatia novae-zelandiae*. Numerous other cushion and mat plants, tufted herbs, rhizomatous sedges, interlacing prostrate shrubs, and other mosses, liverworts and lichens will be present as well. This general sort of vegetation typifies upland basins and gully beds of ranges like the Lammerlaws and Lammermoors. The bogs of high plateaux (e.g. portions of the crests of Rock & Pillar, Maungatua, Blue Mts, Umbrella and Longwood Ranges) tend to have a greater cover of cushion plants and lesser amounts of Sphagnum.

4. *Sphagnum cristatum* can also associate with forests. Beech forests in north-west Otago contain Sphagnum in boggy clearings, or are fringed with Sphagnum cushions at toe- slope forest edge seeps. On the lowland terraces of the Waitutu area, Sphagnum behaves as it does in Westland, colonising wet gentle ground of formerly logged terrace rimu forests. In Fiordland, Sphagnum even grows as hanging lobes on vertical wet valley walls.

UPLAND BOGS : DISTRIBUTION PATTERN

Upland bogs of the type that are attracting Sphagnum harvesting are outlined below to highlight their distribution, to list the sites for which some botanical information is available, and sites for which some conservation status is in place or proposed.

This outline concentrates on those hills and ranges running from Dunedin westward, which together form the great mass of uplifted country which both physically and climatically separates the southern plains and Central Otago. These are ranges with broad tussocky flanks, and extensive crests of gentle relief which catch the prevailing south-westerlies and southerlies. Being cool, moist and with numerous depressions and shallow tributary heads, their extent and variety of upland cushion and moss wetlands is probably unexcelled elsewhere in New Zealand.

No systematic study has been done of these upland wetlands and only a few have been studied in any detail. Botanical information which is available is mostly in unpublished Botany Division reports which should all be held by DOC, in the survey of Scenic Reserves by Allen (1978), the supplementary surveys by G. Ward (in press), and PNA reports of Old Man, Umbrella and Nokomai Ecological Districts. The survey of N.Z. Peat Resources by Davoren *et al*. (1978) although scanty on botanical detail, gives good maps and useful information on peat types and depths. The treatment below is arranged on an Ecological District basis from east to west (Fig. 3).

1. Dunedin Ecological District

Very small Sphagnum bogs occur on the tops of the Dunedin hills:

- Mt Pleasant S.R. Tiny cushion bog (Ward, in press)
- Tiny area in proposed westward extension to reserve (Ward, in press)
- Flagstaff S.R. Tiny area within reserve but not described in Allen (1978)
- Swampy Summit. Bog near tarns, in proposed Silverpeaks S.R (Ward, in press)

2. Waipori Ecological District

- Maungatua Scientific Reserve. Mostly cushion bog; Sphagnum near tarns; Davoren (site 46), Allen (1978), Mark (1955).

- Clarks Junction. Sphagnum dominant, tenure unknown. Davoren (1978) site 39.

- Pioneer Stream and O.P.Q. Historic Reserves. Sphagnum and red tussock (Ward, in press)

- Stony Stream S.R. Sphagnum patches in herbfield seepages (Ward, in press)
- Nardoo S.R. Peaty gully bottoms and tarn-edge Sphagnum (Ward, in press).
- Black Rock S.R. Gully-floor Sphagnum (Allan 1978)
- Deep Stream proposed S.R. Gully-floor Sphagnum (Allan 1978)
- Lammermoor Summit. Sphagnum dominant in peat patches (Davoren, 1978, site 38)
- Lammerlaw Top – Mackays Creek. Sphagnum component in string bogs, gully flushes and large bog. (Johnson & Lee 1988).
- Red Swamp. Extensive bog, much dominated by Sphagnum (Johnson, 1986a).
- Teviot Swamp. Extensive bog, much dominated by Sphagnum (Johnson, 1986a).
- Fortification Stm -L. Onslow head. Sphagnum among red tussock in oxbow system (Johnson, 1986a).
- Middle Swamp, s.w. of L. Onslow. Sphagnum with red tussock. (Davoren, 1978, site 34).

3. Tapanui Ecological District

- Blue Mountains crest. Cushion bog, Sphagnum with red tussock. Davoren (1978) site 48, see also report by Patrick *et al*. (1985), Whisky Gully report by Ward (in press).

4. Rock and Pillar Ecological District

- Rock and Pillar crest near The Castle. Sphagnum and cushion bog patches. Davoren (1978) site 32.
- Great Moss Swamp. Sphagnum flushes survive around the new Logan Burn reservoir, see proposed reserves in report by Johnson (1987).

5. Manorburn wetlands. Sphagnum vegetation types are a minor component in red tussock and wetlands (report by Johnson, 1986b).

- Long Valley, south of Reservoir. Sphagnum and red tussock, possibly now much modified Davoren (1987) Site 31.

6. Old Man Ecological District

The PNA report (Brumley *et al.* 1986) identifies "Carex-moss bog" (presumably Sphagnum inclusive) in at least 8 first priority areas and 6 second priority areas for protection. They are areas 1/10, 1/11, 1/12, 1/13, 2/2, 2/3, 2/4, 2/5, 2/6, 2/7, 2/8. These include some very extensive wetlands, especially at the southern ends of the Garvie and Old Man Ranges. Campbells Creek wetland, noted as the most extensive Sphagnum mossfield recorded for the Ecological District, may be the only one so far which is secured for biological conservation.

7. Umbrella Ecological District

The PNA report by Dickinson (1988) notes three proposed protected natural areas where *Sphagnum cristatum* occurs in sedge-mossfields and moss-cushion fields:

- Whitecoomb -Gem Lake PNA
- Pomahaka River and Boulder Creek headwaters PNA -large plateau wetland.
- Timber Creek PNA

8. Nokomai Ecological District

The PNA report by Dickinson 1987) notes two proposed PNA's where Sphagnum and cushion bogs are an important part:

- Gow Burn
- Upper Dome Burn -along with PNA 1/11 in Old Man District, this includes extensive string bogs which have been studied recently to detailed study by Mark, Dickinson, Johnson et al. (in prep.).

It is of interest to note that the Register of Protected Natural Areas in New Zealand (1984), lists only two legally protected reserves within the last 7 Ecological Districts listed above.

BIOLOGY OF SPHAGNUM IN UPLAND MIRES

These comments derive particularly from my observations on the Lammerlaws, (see reports by Johnson (1986a), Johnson & Lee (1988) and on the Nokomai string bogs (unpublished data). They relate especially to *Sphagnum cristatum*, the commonest species.

Sphagnum grows in extensive carpets, or as hummocky cushions, its main stems densely packed, and its actively growing foliage at the apices. Lower portions of foliage die off as they become shaded, but decompose only slightly, so they accumulate as peat.

Peat depths in these uplands generally range from 1-3 m, sometimes to 5 m. Those southern bogs for which radiocarbon dates are available indicate that peat growth was initiated some 8-10 000 years ago, i.e. after the end of the last major glacial advance. Examination of peat profiles show that Sphagnum has been a major peat-former throughout this period, but sedge rhizomes are also an important component of peats, and at some sites, alternation of peat-forming species is apparent.

Most Sphagnum increase is by vegetative means. Within cushions, the process of branching then decay of lower stems leads to an increase in total stem numbers, so cushions expand laterally as they grow upwards. Sphagnum can regenerate from stem fragments. It also reproduces sexually, via spores, but sporophytes are rarely found, least so in the uplands.

Sphagnum can grow on perfectly level ground where it is fed by rainwater alone, and like other peat formers can eventually create a domed bog, of convex surface profile, because peat accumulation is faster in the centre that at the sloping margins where drainage (and therefore aeration and decay) is greater. Although this sort of site is unusual in sloping uplands, the same principles of Sphagnum growth and peat accumulation apply. On gently sloping surfaces, water moves across and through the vegetation, and all the subtle permutations of water flow, aeration, incoming inorganic sediment from surrounding interfluves, and drainage channels, give rise to mosaics of moss, cushion and sedge mires. The distinction between bog and flush is often indistinct in Otago uplands.

Sphagnum occupies sites with constant water tables. Other cushion plants become dominant wherever the water level fluctuates slightly. *Sphagnum cristatum* will become moribund and die where ponding occurs, though *S. falcatulum* will occupy permanent pools. If a cushion of *S. cristatum* grows too far above the water table it will be subject to dessication by wind and sun, its growth will slow down and it will be colonised by some of the many bog species better adapted to the slightly drier conditions.

In the Lammerlaw and Lammermoor uplands, nearly every stream tributary has a long finger of peaty wetland in its bed. At high altitudes the moss, cushion and sedge cover of the gully bed grade into cushions of snowbank species on the margins. Lower down they are bordered by red tussock, and the precise nature of the bog or flush vegetation will vary from Sphagnum dominant, to other mosses, cushion plants, Carpha or various Carex species, depending on width and profile of the channel. Rock obstructions in the stream bed as well as ‘impoundments’ formed behind peat "dams" create small level bogs interspersed between sections of sloping gulley bed where water seeps down the peat sheet, and with portions of stream channels upon bedrock. Both open stream channels and underground piping further complicate the habitat diversity and the patchy distribution of Sphagnum.

The very large bogs of Teviot Swamp, Red Swamp, and McKays Creek which occupy upland basins partly filled by gently sloping fans of peat, are sufficiently extensive to display various sequential phases of bog vegetation, and to throw some light on the changing role of Sphagnum. Cyclical changes in bog vegetation, detailed in the report by Johnson (1986a), are summarised here (and shown in Fig. 4).

On gentle delta-like fans, convex in contour, *Sphagnum cristatum* is dominant and most vigorous where water is seeping down and across in broad sheets. As the surface of the Sphagnum carpet rises relative to the water table, it is colonised by cushions of comb sedge (*Oreobolus pectinatus*), then by prostrate interlacing branches of *Dracophyllum prostratum*, and subsequently, as the surface becomes higher and drier, by cushions of *Phyllachne colensoi*, the moss *Rhacomitrium lanuginosum*, and lichens. As certain areas of the fans grow higher, movement of the water sheets is redirected, encouraging a new phase of Sphagnum growth. At such sites, the remains of "dry bog" cushion species such as *Phyllachne* can be seen not as cushions but as saucers, as fresh Sphagnum growth surrounds and overtops them. *Sphagnum cristatum* carpets can have another fate too: if downslope lobes or hummocks create a slowing, a stagnation or a fluctuation in water flow the Sphagnum loses vigour, turns brown and is invaded by mats of flood-tolerant *Isolepis (Scirpus) aucklandicus* which is later joined by *Carex* ecies, *Oreobolus* and another phase of cushion plant dominance.

It can thus be seen that Sphagnum growth is an ever-changing phenomenon, dependent on nuances of environmental change (partly self-induced), and on its inter-relationships with the numerous other plant species of upland bogs and flushes. As an example of the floristic richness of these habitats, native vascular plants recorded from Lammerlaw wetlands total 101 species. Species diversity in such wetlands generally far exceeds that of the adjacent and more extensive tussock grasslands, hence the diversity of hosts or habitats for other organisms. In this context too it is worth stressing how many different bog inhabitants stand to be disturbed by the harvesting of one plant, Sphagnum.

The extensive string bogs of the Nokomai area are another example of the way in which Sphagnum can help determine the nature of the bog it occupies. On sloping peat surfaces, preferential accumulation of peat under *Sphagnum cristatum* and associated *Carex* species creates a mound behind which ponding of surface water occurs. Few plants grow actively in the pools, so that peat growth virtually ceases, and over time the pools become deeper and expand laterally as the rims continue upward growth. String bogs on a smaller scale occur also in the tributary heads east of Lammerlaw Top.

IMPLICATIONS FOR SPHAGNUM HARVESTING

Sphagnum and other bog species are very sensitive to changes in watercourse or water table. Trampling by feet or compaction by wheeled or tracked vehicles is very likely to influence water movement in a bog. Cropping of Sphagnum live growth patches, leaving a lower (and wetter) peat vegetation surface may not be favourable to regrowth by Sphagnum. There are no data on growth rates of Sphagnum in Otago uplands. Although Sphagnum growth in lowland may be sufficient to allow re-harvest of 15 cm stem lengths at 3-10 year intervals (De Goldi, 1985) growth rate is likely to be very much slower in the cool climates and shorter growing season of higher altitudes. The only growth rate I can quote for southern New Zealand is from the Awarua Bog, near sea level in southland, where 39 months after fire, Sphagnum stems have grown to 3 cm long on newly established plants upon the peat surf ace.

Another possible consequence of Sphagnum harvesting in gulley bed bogs and flushes is that weedy naturalised species might invade, following physical disturbance of the peat surface. Near Great Moss Swamp and Red Swamp, peaty streamsides and flushes have been invaded by the following naturalised plants mainly on peaty mineral soils where trampled and enriched by livestock: *Juncus articulatus, J. effusus, Carex ovalis, Agrostis stolonifera, Poa pratensis* and *Holcus lanatus.*

BIOLOGICAL CONSERVATION OF UPLAND BOGS

The onset of Sphagnum harvesting creates a new urgency for the identification of representative natural areas for protection, and for the implementation of existing proposals for reserves. Of the Ecological Districts discussed above, the Old Man, Nokomai, Umbrella, and Rock & Pillar have been subject to overall survey and PNA-type proposals. Wetlands of the Blue Mountains (Tapanui E.D.) are presumably under some form of protection by DOC already. It is the Waipori and Manorburn Districts which deserve priority for PNA-type survey, not only to get an overall picture of their wetlands but also of their tussock grasslands. The two vegetation types are closely associated, and would ideally be protected in tandem in any natural areas proposed for protection. To date, tentative proposals for reserves in both districts have lacked a good measure of their representativeness. There is another reason for considering the tussock grasslands and the wetlands together in the context of their conservation. As the predominant cover of and of the catchment of every wetland, tussock grasses play a part in water yield through fog interception, and must act as a buffer for the infertile wetlands against such influences as aerial topdressing.

HYDROLOGICAL IMPORTANCE OF UPLAND BOGS

Many wetlands play an important role in filtering water, absorbing water during heavy rain or flood events, and maintaining regular outflows during dry spells. There does not appear to be any detailed information on the relative roles of peaty mires and tussocky interfluves in water regulation in the Otago Uplands. I have spoken to David Murray, Geography Dept, Otago University (presently on sabbatical leave in Canterbury), who had made a research proposal to NWASCO to study this question, but the proposal seems to have died with NWASCO. In the discussion supporting his research proposal, Murray makes the point that the conventional view that wetlands attenuate flood peaks and sustain low flows for long periods may not apply to these sloping upland wetlands. Dick Martin, formerly of Water Resources Survey has commented (pers. comm.) that from his extensive casual observations, the gulley bogs are permanently saturated with water, and that they are more likely to be the result of a constant inflow of water from the deep regolith of the adjacent interfluves. McSaveny & Whitehouse discussing the significance of snow tussocks to water yield also comment on the role of the thick schist-debris mantle (as well as bogs and tarns) in storing water and letting it out slowly. They also note that in the Otago snow-tussock uplands that water is delivered at moderate rates for long periods, that frequency of heavy rains is low and that erosion rates and sediment yields are consequently low in this country. According to Barry Thomas, Water Resources Survey, Dunedin, his group have no detailed information specifically on wetland hydrology for the Otago uplands. Although the gulley wetlands may remain virtually saturated all year, slight lowering of water table in basin bogs such as Teviot Swamp is more likely during dry spells (Dick Martin, pers. comm.). Brian Patrick (pers. comm.) reports seasonal drying of Sphagnum hummocks in the Lammerlaws; his observation correlates with times of emergence of Sphanum-inhabiting insects. In summary it must be stressed that there is still no hard data to assess the contribution of these upland wetlands.

DISCUSSION

Conservation of Sphagnum bogs involves more than just the formal protection of selected representative portions. This aspect should certainly have highest priority especially insofar as it establishes permanent baselines of habitats to be retained in an unmodified state. But conservation must also be practised on all wetlands, including those which are harvested for Sphagnum.

Just as it is possible to seek the best available sites for protection, so too it should be feasible to seek harvesting sites there is little conflict with biological conservation, where downstream hydrological effects are likely to be minimal, where impacts of Sphagnum harvesting can be monitored from the very outset, and where experimental trials can be aimed at maximising Sphagnum regrowth. This survey and research input should be seen by the industry and by agencies responsible for land management, not as a thorn in the side, but as a benefit to the economy of both province and country in the long term.

The economic viability of Sphagnum harvesting as an export activity can only be properly assessed if it includes the research and management costs of ensuring the operation is sustainable and does not have adverse effects on land and water systems.

On a speculative note it is relevant to ask the question might climate change affect the future of upland bogs, with or without harvesting of Sphagnum?" Wetlands of all sorts are very sensitive to secular changes in wetness and temperature.

Stratigraphic analysis of peat deposits incorporating regular samples for dating, has shown that rate of peat accumulation is often not steady, but can be interrupted by periods where peat growth has slowed or ceased. (A peat surface can even decline at a time when conditions favour decay of organic matter rather than its accumulation). The presence of buried wood layers in bogs (even upland ones) which today have a non-woody vegetation cover, is indicative of major changes in climate in the past. The implications are that a major peat-former like Sphagnum has probably fluctuated widely in importance at different times.

Any attempt to comprehend its present roles must be fitted into what we can deduce of its response to former climatic cycles.

RESEARCH NEEDS

This preliminary outline of survey and research needs is arranged roughly from the general to the specific.

1. PNA type survey of the Waipori and Manorburn Ecological Districts. Pending full survey, an initial inventory of wetland sites and systems could be carried out to identify those of high value for biological conservation, and those where Sphagnum harvesting would have least impact on other values.

2. Literature review of both overseas and New Zealand data relevant to Sphagnum vegetation and harvesting in Otago.

3. Detailed study of the role of Sphagnum in a selected range of vegetation types at different altitudes, including studies on:

    (a) growth rates of Sphagnum.
    (b) relationships of different Sphagnum species to each other and to nutrient and water regimes

(c) monitoring of cycles of succession in Sphagnum bogs to determine their rate
(d) monitoring of recovery of Sphagnum in harvested bogs
(e) experimental manipulation of harvested habitat towards maximising Sphagnum regrowth.

4. Hydrological studies on the role of upland wetlands.

5. Studies on upland bogs as habitat for birds, invertebrates etc.

Urgency should be given at least to item 3(d), following on-site inspection of sites which have been harvested already, and of those for which harvesting is contemplated.

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Sphagnum cristatum   Sphagnum falcatulum   Sphagnum squarrosum

Fig 1 The major peat-forming Sphagnum species found in Otago upland bogs.

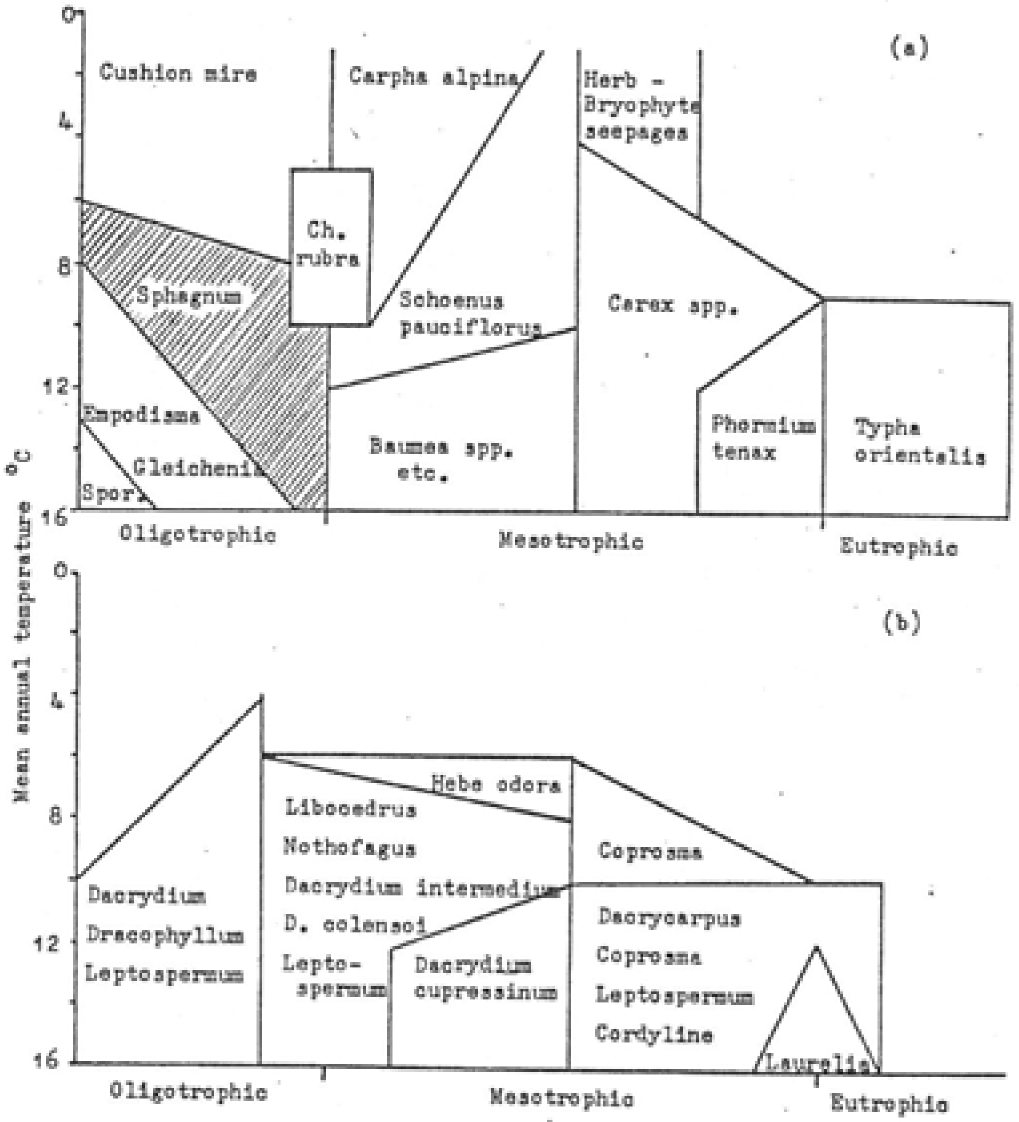

Figure 2. Generalised relationships of the principal mire species in New Zealand in relation to mean annual temperature and overall fertility: (a) herbaceous vegetation, (b) forest and scrub. (Ch. = Chionochloa; Spor. = Sporodanthus traversii).

Fig 2. The position of Sphagnum (shaded, above) in relation to other principal mire species. (From Dobson, Andrew T. 1979. Mire types of New Zealand. Proceedings of the International Symposium on Classification of Peat and Peatlands. International Peat Society 1979.)

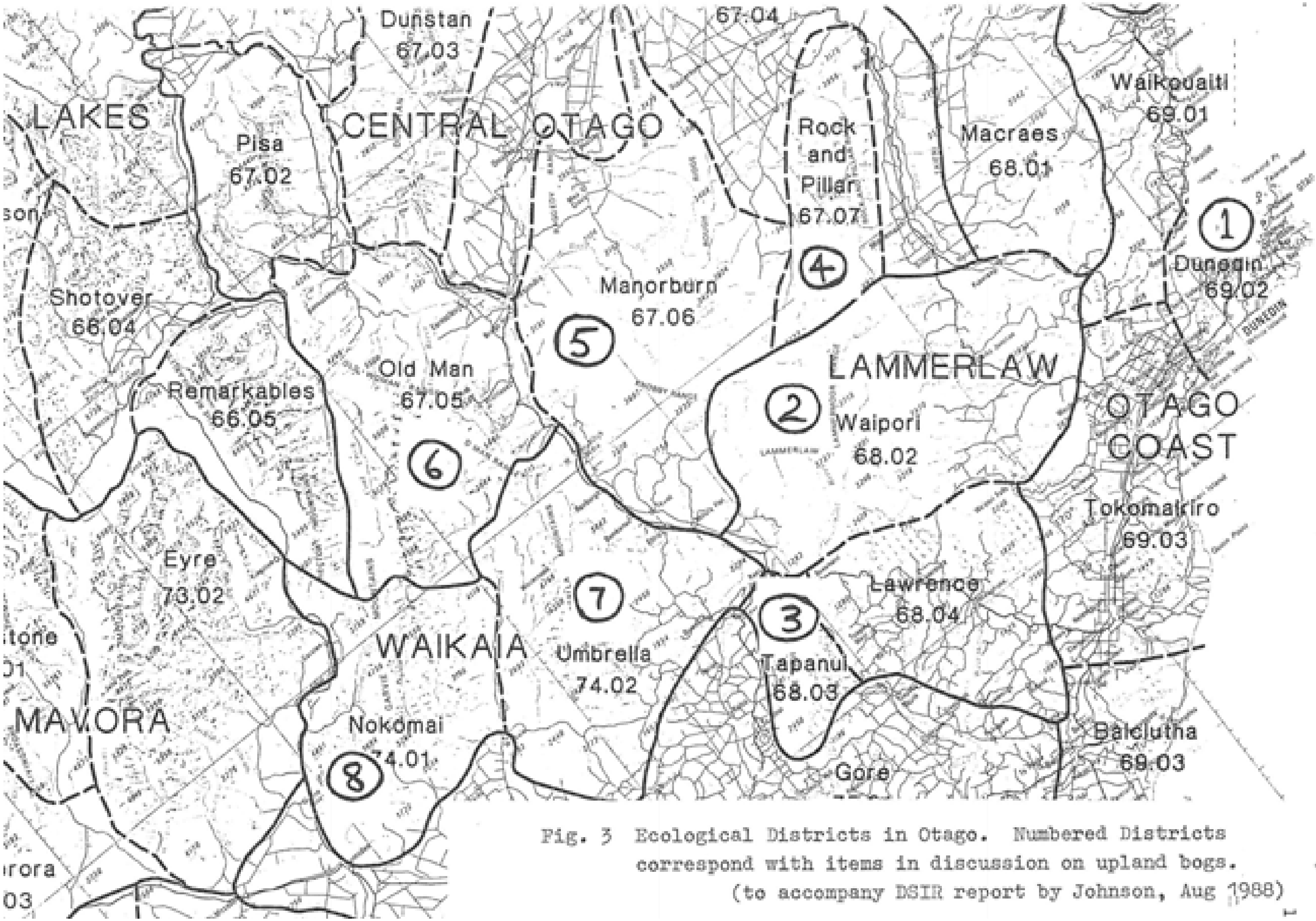

Fig. 3 Ecological Districts in Otago. Numbered Districts correspond with items in discussion on upland bogs. (to accompany DSIR report by Johnson, Aug 1988)

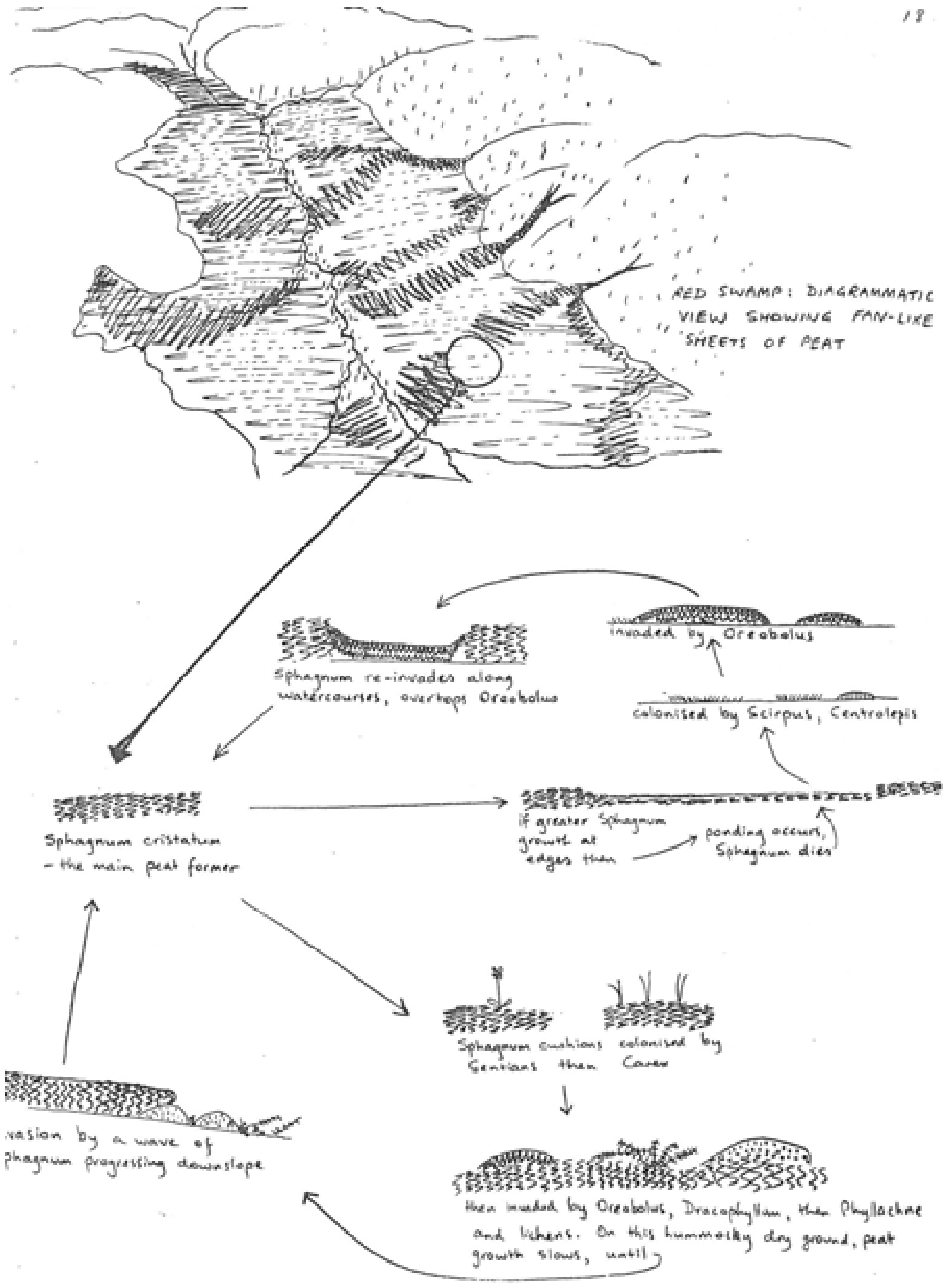

FIG 4 Cycles of bog vegetation at Red and Teviot Swamps
(From Johnson, May 1986, report on Lammerlaw Range uplands)