THE MOUNT WELLINGTON STRING BOG, TASMANIA

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(with four text figures)

WHINAM, J. & KIRKPATRICK, J.B., 1994 (30:vi): The Mount Wellington string bog, Tasmania. *Pap. Proc. R. Soc. Tasm.* 128: 63–68. ISSN 0080–4703. https://doi.org/10.26749/rstpp.128.63 Department of Geography and Environmental Studies, University of Tasmania, GPO Box 252C, Hobart, Tasmania, Australia 7001; JW now Parks and Wildlife Service, GPO Box 44A, Hobart, Tasmania, Australia 7001.

A string bog ecosystem occupies part of a subalpine valley on Mt Wellington, Tasmania. The steps in the subsurface blockstream preferentially underlie pools. Variations in pool hydrology are independent of pool size. There is a correlation between pool shape and pool type, an oval shape being indicative of more recent secondary pool formation, primary pools with rocky floors being variably shaped. Variation in the bog vegetation is closely related to variations in slope, drainage and peat depth. The major changes in abundance of pollen types are related to changes in abundance of charcoal. The Mt Wellington string bog complex appears likely to have been formed by similar processes to those postulated to have resulted in the string bog system at Mt Field.

Key Words: string bogs, morphology, hydrology, vegetation, pollen, Tasmania.

INTRODUCTION

String bogs are common in polar and boreal regions. They have been defined as "areas of peatland characterized by ridges of peat and vegetation, interspersed with depressions that often contain shallow ponds" (Washburn 1979: 174). The ridges, or strings, can be up to two metres in height and may be tens of metres long (Gore 1983). Patterned peatlands, resembling string bogs, in Kosciusko National Park, New South Wales, were described by McElroy (1951) and Costin *et al.* (1979). Millington (1954) described a *Sphagnum* hummock–hollow regeneration complex in northeastern New South Wales. In Tasmania, Martin (1940) and Jackson (1973) noted the existence of features resembling string bogs on Mt Wellington and the Central Plateau respectively, and there have been recent detailed investigation of the dynamics of a bolster heath string bog at Newdegate Pass, Mt Field (Kirkpatrick & Gibson 1984, Gibson & Kirkpatrick 1992).

Most studies of string bogs have focussed on developing and validating hypotheses related to their origin and development (Walter 1977). These hypotheses vary in their recourse to biotic, gravitational and periglacial processes. However, the evidence from different parts of the globe tends to suggest that the string bog landform is distinctly multigenetic (Moore & Bellamy 1974). In Tasmania, Kirkpatrick & Gibson (1984) argued that the Newdegate Pass string bogs (which are approximately 60 km WNW of Mt Wellington) had developed on an underlying stepped block stream by differential growth of bolster plants in response to drainage diversions created by their initial establishment. They observed that ponds tended to drain by tunnel erosion after their dams exceeded a certain height, and that new dams began to form in the rocky bottom of the old ponds. They suggested that pond drainage was most rapid where overland flow was greatest. Kirkpatrick & Gibson (1984) concluded that, although there were cyclic elements in the history of the bog, any rapid short-term changes were necessarily degradational. Their conclusions were largely based on surface and subsurface morphology. The string bog on Mount Wellington (fig. 1) is morphologically similar to that at Newdegate Pass, while having few higher plant species in common.

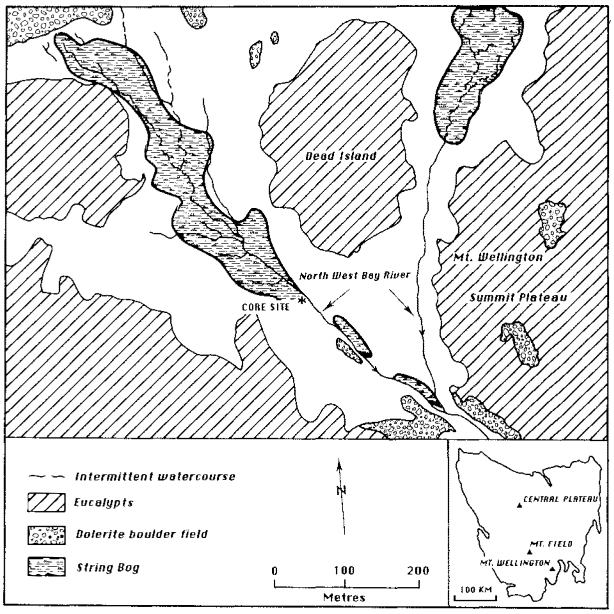

FIG. 1 — Location of ponds and streams on Mount Wellington.

The major aim of this paper is to describe and explain variation in the Mount Wellington string bogs, using quantitative data on vegetation, pool morphology and hydrology.

METHODS

Morphology and Hydrology

The surface topography was surveyed along a transect through the string bog sequence, using a dumpy level and Carr staff. The subsurface topography was measured on the lower part of the sequence at 1 m intervals, and at 0.5 m intervals on four transects radiating out from each of 20 intensively studied pools. Peat depth was determined by inserting a 2 m long metal rod through the peat until rock or gritty clay prevented further penetration. Step length was measured along the long transect by taking a distance between the top of a protuberance in the subsurface topography and the next upslope point at the same altitude.

Twenty pools were selected for hydrologic investigations on the basis of the following criteria: they appeared unlikely to dry out during the summer (to facilitate comparable measurements); they represented a range of sizes and depths; they varied in their location in relation to the main drainage lines. Water depth was measured on reference poles 17 times over seven weeks during summer. A pit 0.3 m × 0.3 m × 0.5 m was dug beside the pool furthest upstream to measure fluctuations in the water table. A Bureau of Meteorology rain gauge was placed in the bog. Rainfall and water-table height were recorded at the same time as water depth.

Eighty other pools were also investigated. They were selected randomly in the field and measured in order to assess variations in size of pools, variations in water depth, shape and rockiness of pools, and dam wall and aquatic vegetation. This information was tabulated with similar information from the 20 selected pools, to give an indication of the range of physical properties of pools in the string bog complex.

Vegetation

Four quadrats, measuring 2 m × 1 m, were laid out at points north, east, south and west of each of the 20 selected pools. Quadrat size was determined by constructing species area curves (Mueller-Dombois & Ellenberg 1974). These quadrats were located as near as possible to the longest/broadest points of the pools. The pool wall was used as the quadrat boundary with aquatic vegetation being excluded.

Species cover-abundance was noted, using the Braun-Blanquet system (Mueller-Dombois & Ellenberg 1974). Where possible, plants were identified to species level. Species nomenclature follows Buchanan *et al.* 1989.

The quadrat species cover codes were used as the input to a polythetic divisive classification using TWINSPAN (Hill 1979). Chi-square was used to test the significance of associations between floristic communities and environmental variables.

Palynology and stratigraphy

A Livingstone corer was used to extract an 0. 74 m core, which compressed to 0.51 m during extraction. The core site is located approximately in the centre of the northern mire complex in a flat area immediately in front of a pool wall (Whinam 1985). The vegetation at the core site is dominated by *Empodisma minus*, with *Poa gunnii*, *Craspedia alpina*, *Helichrysum backhousii* var. *oreophila*, *Olearia algida*, *Helichrysum scorpioides* and *Acaena montana* also present.

Three pollen samples were taken from the surface of the peat 10 m, 20 m and 40 m from the site of the extracted core. These were counted and analysed to provide a modern-day pollen analogue for interpretation of the core (Rymer 1978, Caseldine 1981).

The core sampling interval was 0.1 m, with a few intermediate samples at 0.05 m intervals. The samples were leached with HCl and processed using the method of Faegri & Iversen (1975). The samples were stained with safranin and mounted in glycerol. Exotic *Lycopodium* spores were inserted into the pollen sample before treatment to allow measurement of the concentration of pollen (Stockmarr 1971).

The slides were systematically scanned with a Wild binocular microscope on × 200 magnification, with × 400 magnification being used to identify initial and problem pollen. Pollen and spores were checked against the reference collection in the Department of Geography and Environmental Studies, University of Tasmania. The results are based on a minimum pollen sum of 300 grains, with an average count of 419 grains/spores at each interval sampled. Carbonised particle concentrations were estimated by counting all carbonised particles greater than 20 microns and calculating relative and absolute numbers as a percentage of the pollen sum (Hope & Peterson 1976).

RESULTS AND DISCUSSION

Bog morphology and hydrology

The string bogs are located in the headwaters of the North West Bay River (fig. 1). The general slope of the western part of the bog varied from 2.1° to 3.6° The mean area of pools was 25.33 m^2 (n = 100, s.d. = 30.9 m^2, range = 0.3–170m^2), with a mean maximum depth of 0.54 m (s.d. = 0.23 m, range = 0.18–1.10 m^2). Fourteen of the hundred pools had a peat base. The rest had floors composed of rocks and organic detritus with the relative area of peat floor being variable, but being on average 60%. Although aquatic vegetation cover was generally negligible, only 13 of the pools lacked any higher plants, while 71% contained aquatic *Isolepis* spp. and 52% contained *Myriophyllum pedunculatum.* The only other vascular plant found in the pools was *Ranunculus glabrifolius* (3%).

Forty per cent of the pools were elongate or oval, with the long axis along the contour, 26% were tear-drop shaped, the remainder being irregular in shape. Oval ponds had significantly more peat floors than could be expected by chance (chi-square = 14.3, d.f. = 2, $P < 0.001$). The ponds proved to be preferentially located on steps in the underlying boulder stream (fig. 2). Pools are preferentially located on step lengths >2.5 m (chi-square = 6, d.f. = 2, $P < 0.05$). All the steps without pools were 2.5 m or less in extent. Peat depth measurements taken on two axes across the pools and 2 m either side indicate that there is often a tall boulder underlying the front of the dam, a phenomenon also observed at Newdegate Pass (Kirkpatrick & Gibson 1984). The water levels in the 20 ponds and the ground water pit fluctuated in unison (fig. 3). There was no relationship between the size of the pond and the amplitude of fluctuations (fig. 3). The fluctuations were related to rainfall events (fig. 3).

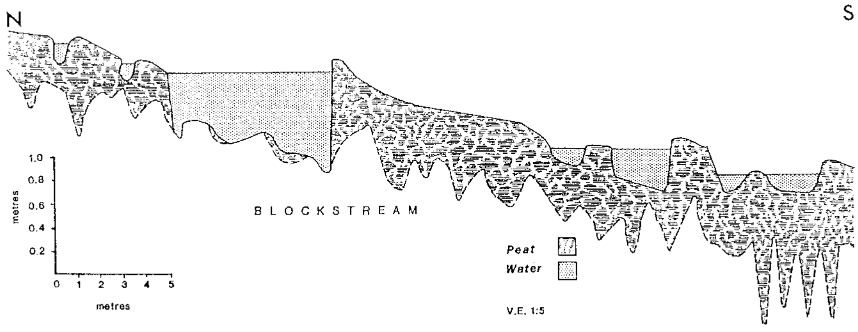

FIG. 2 — A cross-section of part of the northern string bog.

Vegetation

Most of the bog was burned in the severe 1967 bushfires, including all the sampled quadrats. Fires have played a major role in maintaining the seral nature of the vegetation on Mount Wellington with severe fires being recorded this century in 1900, 1924, 1939, 1947, 1965 and 1967 (Ratkowsky & Ratkowsky 1976, 1977). Small unburned areas are dominated by 1 m tall shrubs, mostly *Richea scoparia* and *Orites acicularis.* The burned part of the bog consists of a tall, alpine herbfield (*sensu* Kirkpatrick 1983), dominated by either *Astelia alpina* or *Empodisma minus* with occasional emergent composite shrubs (*Helichrysum hookeri, H. backhousei, Olearia algida* and *O. obcordata*). Seedlings of *Richea scoparia, R. gunnii* and *Orites acicularis* are present in sufficient density to eventually form closed heath. *Astelia alpina* tends to be more prominent along streams and on the margins of ponds than in the interstices between these features, where *Empodisma* usually dominates.

Sphagnum commonly dominates in string bogs in areas with uniformly cool, moist climates (for example, northern Europe). In Tasmania, as in New Zealand, other species, such as *Empodisma minus* and *Astelia alpina,* are active peat producers (Campbell 1983). *Sphagnum* is localised in its occurrence in the Mt Wellington string bogs.

The taxa with high constancy throughout the bog are *Helichrysum hookeri, Astelia alpina, Olearia algida, Empodisma minus, Poa gunnii, Craspedia alpina, Epacris serpyllifolia* and *Carex* sp. (table 1). The TWINSPAN sorted table contained four moderately distinct floristic groups: group 1 is characterised by the presence of *Drosera arcturi, Sphagnum cristatum* and *Euphrasia collina*; group 2 has low representation of the above species, but shares with group 1 a high frequently of *Gleichenia alpina* and an absence of the species that characterise groups 3 and 4; group 3 is best characterised by high frequencies of *Uncinia compacta* and *Celmisia asteliifolia;* group 4 is best characterised by *Helichrysum rutidolepis* and *Hierochloe redolens* (table 1).

The distributions of the floristic communities are strongly related to slope (chi-square = 43.6, d.f. = 6, $P < 0.001$), with communities 4 and 3 being twice as common as expected on the very gentle slopes (<2°), community 1 being twice as common as expected on the gentle slopes (2–6°) and community 2 being one and half times as common as expected on the moderate slopes (>6°). Community 4 is also preferentially located on the downslope walls of ponds (chi-square = 15.7, d.f. = 1, $P < 0.001$), whereas community 3 is preferentially located away from the edge of ponds (chi-square = 37, d.f. = 1, $P < 0.001$). Community 1 occurs less than half the times that could be expected around ponds

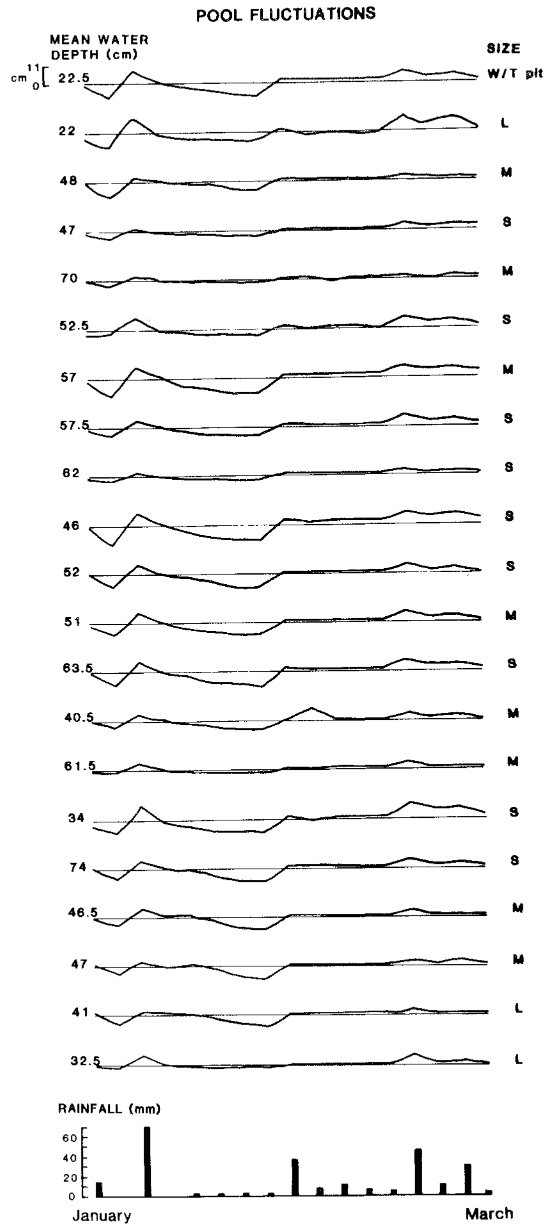

FIG. 3 — Fluctuations in the water level of pools and the watertable (W/T) pit and incidences of rainfall. S = small (< 10 m²), M = medium (10–50 m²), L = large (> 50 m²). Pools are in order, down the string bog sequence.

with low water-level amplitudes (chi-square = 2.92, d.f. = 1, $P < 0.05$). The cover ratio *Empodisma/Astelia* is greatest for community 3 and differs little between the other

TABLE 1
Percentage frequency of most frequent taxa by classificatory group

	TWINSPAN group			
	1	2	3	4
No. of quadrats	17	28	13	30
Drosera arcturi	71	–	8	–
Sphagnum australe	76	3	–	–
Myriophyllum pedunculatum	29	–	–	–
Ourisia integrifolia	35	–	8	3
Ranunculus glabrifolius	29	–	8	6
Gentianella diemensis	18	–	8	–
Bellendena montana	12	7	8	–
Baeckea gunniana	47	18	15	3
Helichrysum backhousii var. *backhousii*	65	25	46	3
Euphrasia collina ssp. *diemenica*	71	14	62	37
Gleichenia alpina	94	89	8	7
Richea gunnii	65	46	38	13
Oreobolus spp.	29	11	15	27
Epacris serpyllifolia	100	86	45	63
Carex sp.	88	82	–	37
Craspedia alpina	100	89	92	93
Poa gunnii	94	82	92	96
Empodisma minus	100	89	100	100
Olearia algida	94	86	69	80
Astelia alpina	88	71	69	97
Helichrysum hookeri	65	82	69	80
Luzula sp.	11	–	–	–
Orites acicularis	11	–	8	–
Uncinia compacta	–	4	100	16
Celmisia asteliifolia	29	18	54	7
Carpha alpina	6	11	15	7
Helichrysum backhousei var. *oreophilum*	12	43	92	90
Sphagnum cristatum	18	4	69	40
Danthonia sp.	–	–	15	–
Helichrysum rutidolepis	18	4	46	70
Acaena montana	6	–	46	47
Olearia obcordata	6	–	54	47
Asperula gunnii	12	14	8	40
Hierochloe redolens	6	4	–	53
Richea scoparia	–	21	16	27
Helichrysum ledifolium	–	–	–	13
Epilobium sp.	–	–	–	7

communities, although the greatest cover of *Astelia* is in community 4.

As all of the bog is constantly moist, the distribution of species and communities cannot be related to variations in site dryness. However, the above analyses do imply a strong differentiating role for soil aeration. Thus, community 4 occurs preferentially on dam walls and around ponds with large water fluctuations. Good aeration allows for high overlapping cover, and this high cover excludes many of the smaller taxa common in community 3, which occurs between the ponds and on the walls of ponds with low amplitudes. Community 2 occurs beside pools on the steeper slopes, where aeration would be generally better than on gentler slopes. Community 1 differs from community 2 only in its possession of a group of species usually associated with standing water, and its predilection for pools on slightly gentler slopes.

Vegetation history

Absolute and relative pollen diagrams and charcoal and pollen and spore concentrations are shown in figure 4. The pollen taxa that constitute most of the count fall into three distinct classes of stratigraphic pattern: (1) Gramineae (Poaceae) pollen numbers decline from 0.5 to 0.2 m in

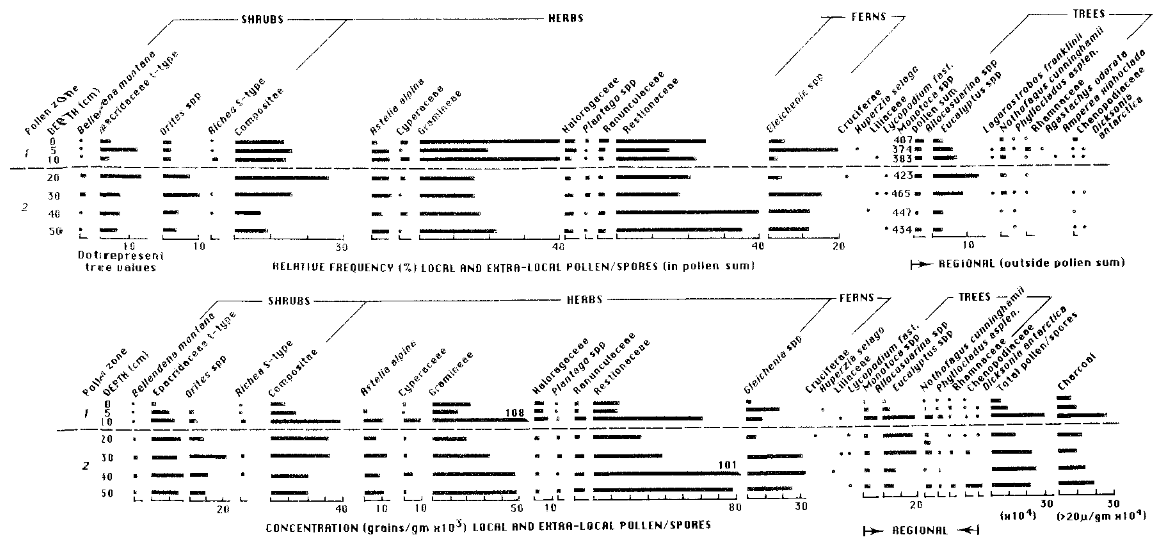

FIG. 4 — Absolute and relative pollen diagrams, with charcoal, pollen and spore concentrations.

zone 1 and then increase in zone 2; Restionaceae pollen shows a decline from the high values at 0.4 m; (2) *Astelia*, Haloragaceae and Ranunculaceae vary little in their abundance; (3) Copositae (Asteraceae), Epacridaceae (T-type), and *Orites* show a decrease in numbers from zone 1 to zone 2. The charcoal counts are positively related to Gramineae pollen concentration (Spearmans r = 0.83, $p < 0.05$).

The above data are consistent with a history of declining (zone 1) and then increasing (zone 2) fire frequency on the Mt Wellington bogs, as the Gramineae increase their cover after fire, *Orites acicularis* and many Epacridaceae species take many decades to recover their cover, while *Astelia* remains constant in cover (Kirkpatrick & Dickinson 1984). The spatial patterning of *Astelia* and Restionaceae (*Restio* and *Empodisma*) suggested that *Astelia* might be more important than Restionaceae in the early stages of dam formation. However, there is no indication of this phenomenon in figure 4.

Several features of the bog and the core suggest a mid-Holocene origin for the string bog. The absence of the early Holocene *Pomaderris* peak (Macphail & Jackson 1978; Macphail 1979; Thomas 1984) on a *Pomaderris*-rich mountain (Martin 1940), in combination with the other bog characteristics, such as peat depth, extent of the deposit and vegetation history, strongly suggest an age of less than a few thousand years. Such an age would be consistent with the conclusions of Caine (1983) and Macphail & Hope (1985), who suggest that there has been a marked resurgence in bog growth after c. 3500 BP. However, reservations have been expressed about this putative resurgence (Young 1986).

General Discussion

The Mt Wellington mire in strict definition is a mildly acidic, minerotrophic fen. This string bog sequence is probably close to the climate margin for such formations (Barber 1981, Moore & Bellamy 1974, Young 1983). The annual average minimum temperature is 1.1°C and the average maximum temperature is 7.3°C. Average annual precipitation is approximately 1250 mm (Macphail & Peterson 1975). The hummocks and flarks associated with string bogs are only poorly developed, compared to sequences in the Northern Hemisphere. Thus, the pools are both fewer and smaller on Mt Wellington than in string bogs in the Northern Hemisphere reported in the literature, and the strings or ridges are less elongate. However, the surface and subsurface topography, vegetation and surficial features at Mt Wellington resemble similar descriptions from Newdegate Pass, Tasmania (Kirkpatrick & Gibson 1984), the Central Plateau (Jackson 1972) and Arthur's River, New Zealand (Knox 1969), except that their micro-topographic expression has been reduced by localised peat losses apparently due to firing of large bushes.

The broadscale surface and subsurface topography appear to be related, with the string bogs being "stepped", with a boulder often forming part of the dam wall. The large sizes of some pools away from major drainage lines suggest that these are stable pools which have existed for some time. Many of the dam walls of these pools are built up above the surrounding peat cover. Smaller pools along the main drainage channels appear to be less stable, with vegetation actively forming dams in some cases and collapse of dam walls being evident in others.

The significant number of large pools with rocky floor and no obvious depth of peat supports the supposition that these pools formed very early in the development of the sequence. The positive correlation of oval shape with ponds formed in peat with no obvious rocks supports the hypothesis that these are more recent, secondary formations (Birks 1972, Seppala & Koutaniemi 1985).

It is likely that fire has played a role in controlling the nature of the bog vegetation and has possibly impeded peat accumulation. The pollen record suggests a fairly stable subalpine fen vegetation throughout the development of the mire with some changes in dominance and relative species abundance. A simultaneous increase in charcoal and grass pollen, combined with the appearance of two *Pinus radiata* pollen (5 cm sample) in the pollen record, suggests that fire has increased since European settlement (Whinam 1985).

As geomorphic evidence suggests that mean annual temperatures were depressed by 6°–8°C during the Last Glacial (Kiernan 1983), and the mean temperature at the study site is 4.1°C today, it seems likely that the string bogs are Holocene in origin.

Warmer post-glacial temperatures would have allowed the development of vegetation on interstitial clays in the fossil blockstreams. As this vegetation decomposed, peat would have begun to form. Vegetation growing on this peat base would then be able to divert and redistribute surface flow, thus forming dams. Accumulation of peat would then have resulted in all but the largest boulders being covered, similar to the process proposed for Newdegate Pass (Kirkpatrick & Gibson 1984). Secondary pools could then form in micro-topographic hollows in the peat. The development of at least some of these hollows may have been related to fire damage.

The future of the bog may depend on fire frequency. Peat erosion is occurring at its lower and upper margins. If, as seems likely from the evidence of dead shrubs dating from 1967, their erosion is caused by firing, the bog will continue to retreat if fire is a frequent event.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of Russell Bauer and Richard Hale with fieldwork.

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(accepted 16 February 1994)