The Flow Country

The peatlands of Caithness and Sutherland

R A Lindsay, D J Charman, F Everingham, R M O'Reilly,
M A Palmer, T A Rowell and D A Stroud

Edited by D A Ratcliffe and P H Oswald

Contents

Annex

1 Vegetation and small-scale patterning

As part of the programme for the NCC's revision of its guidelines for the selection of biological Sites of Special Scientific Interest, a number of sites, taken from the main areas of peatland distribution in Britain, were selected for detailed survey between 1982 and 1985. The survey methods were designed to identify geographical trends in both mire surface pattern and vegetation and to determine whether any relationships existed between these two features. As part of this survey, seven sites in Caithness and Sutherland were examined.

In order to illustrate the range of detailed surface patterning within and between sites across Caithness and Sutherland and the distribution of vegetation types within these, data from five of the sites are presented here. These transect profiles are merely examples of the range of microtopography

	D.1	D.2	D.3	D.4	D.5
Cladonia arbuscula	I				
Cladonia impexa	III*				
Arctostaphylos uva-ursi	IV*			I	
Bare peat	V*	III*		I	
Sphagnum tenellum	I				
Hypnum cupressiforme	IV*	IV*			
Calluna vulgaris	V*	V*	II		
Eriophorum vaginatum	IV		II	I	
Erica tetralix	IV	I	III	I	
Trichophorum cespitosum	I			I	
Pleurozium schreberi		II			
Sphagnum rubellum	III	I	V*	II	
Eriophorum angustifolium	II	V*	V*	IV*	
Empetrum nigrum		V*	III	I	
Plagiothecium undulatum		I			
Narthecium ossifragum	I	I	IV	I	I
Aulacomnium palustre		I	II		
Hypogymnia physodes					
Hylocomium splendens					
Listera cordata					
Rhytidiadelphus loreus					
Vaccinium oxycoccos					
Acrocladium stramineum					
Odontoschisma sphagni					
Drosera rotundifolia				I	
Drosera anglica				I	
Polytrichum commune				I	
Sphagnum papillosum			II	IV*	I
Sphagnum cuspidatum				V*	
Menyanthes trifoliata				II	I
Sphagnum auriculatum				I	
Open water					V*
Eleocharis multicaulis				II	
Wet bare peat					IV*

Table 14a

Synoptic table for Dubh Lochs of Shielton. Constancy values are indicated in Roman numerals. High abundance is indicated by an asterisk.

and vegetation patterning, to show how the two interact and to emphasise the way in which pattern and vegetation change from east to west across the two Districts. The full range of variation is much greater than is shown by these examples and should be a major element in determining the scope of a mire protection programme.

Methods of survey and analysis

Transect lines were used as the standard sampling method on each site in the hope that the scale of pattern for both vegetation and microtopography would emerge from the study, rather than be imposed by the sampling method, Kershaw (1973) stated that transects with contiguous quadrats are most appropriate for sampling within small-scale environmental gradients. The method had been used to some effect by Godwin & Conway (1939) on Cors Tregaron in Wales.

Like Godwin & Conway, the NCC surveyors took 10 cm squares as the basic mapping unit, but these lay contiguously within a transect of 0.5 m x 2 m. Five transects were taken from each site and were placed so as to sample as wide a range of microtopography as possible. The relative abundance of each vegetation type and zone in the microtopography within the transect did not therefore reflect the overall abundance on the site.

Species were recorded on a three-point scale - Dominant, Common, Rare - within each 10 cm square, and the height of each square was noted (±0.5 cm) relative to an arbitrary datum. Stereo-photographs were taken of each transect. The vegetation records were then analysed by using TWINSPAN (Hill 1979), and the resulting noda were mapped onto a representation of the transect grid. The TWINSPAN noda were recombined up the hierarchy until the distribution of noda on the transect corresponded with any vegetation pattern discernible on the stereo-photographs; i.e. the final noda existed in a recognisable form in the field. The details of the noda for each site were drawn up into a synoptic table with the use of a computer spreadsheet.

The height data for the transects were then plotted on the transect grid. The range of heights for each nodum and its mode were recorded. The location of the average water table, which is the single most important limiting factor within the microtopography, was taken to be represented by the upper limit of vegetation noda characterised by *Sphagnum*

	S.1	S.2	S.3	S.4	S.5	S.6
Sphagnum imbricatum	V*			I		
Arctostaphylos uva-ursi		I				
Cladonia gracilis		I		I		
Cladonia impexa		V*	II			
Racomitrium lanuginosum		I				
Pleurozium schreberi			III			
Aulacomnium palustre						
Cladonia uncialis						
Bare peat	IV*	III		II		
Calluna vulgaris	V*	V*	V*	III		I
Sphagnum rubellum	V*	I	IV*	III		
Erica tetralix	II	III	IV*	II		
Drosera rotundifolia	III	I	II	II		I
Hypnum cupressiforme				I		
Menyanthes trifoliata	II			I		
Mylia anomala				I		
Narthecium ossifragum	II	II	III	III		I
Trichophorum cespitosum	I	I		I		
Pleurozia purpurea	I			I		
Eriophorum vaginatum	IV*	III	III	II		
Betula nana				I		
Eriophorum angustifolium	II	V*	III	III	III	I
Sphagnum tenellum			II	II		I
Sphagnum papillosum	II	I		V*	II	
Drosera anglica	I			II		I
Sphagnum magellanicum				I		I
Eleocharis multicaulis				I		
Sphagnum cuspidatum	I			III*	V*	IV
Sphagnum auriculatum						I
Wet bare peat						V*

Table 14b

Synoptic table for Strathy Bog. Constancy values are indicated in Roman numerals. High abundance is indicated by an asterisk.

	C.1	C.2	C.3	C.4	C.5	C.6	C.7
Cladonia arbuscula							I
Mylia taylorii	IV	I					
Carex pauciflora	III	II					I
Sphagnum rubellum	V*	V*	II	I	V*	I	
Eriophorum vaginatum	III	IV*	II	I	II		I
Carex dioica		I			I		
Pinguicula vulgaris			I				
Cladonia uncialis	I		II		I		
Cladonia impexa	II	I	V*	I	I		
Hypnum cupressiforme			I		I		
Calluna vulgaris	V*	IV*	V*	II	IV*		I
Sphagnum magellanicum	III	III			II		I
Drosera rotundifolia	III	II	I	I	IV		I
Bare peat	I	I	V*	II	III		
Narthecium ossifragum	IV*	IV	V*	V*	I	II	
Potentilla erecta		I		I			
Racomitrium lanuginosum	I		V*	III*			
Sphagnum papillosum	I	V*	I	III*	V*		I
Sphagnum tenellum	I	II		I	III		I
Erica tetralix	I	I	II	II	IV		I
Pleurozia purpurea			I	III			
Trichophorum cespitosum			IV*	III	I		I
Molinia caerulea		I	I	V*			I
Polygala vulgaris			I	I			
Myrica gale		I	I		II		II
Molinia litter		I		II	I	II	
Drosera anglica		I		I	I		I
Drosera intermedia					I		I
Eriophorum angustifolium	I	I	II	II	III	III	IV*
Menyanthes trifoliata				I			
Sphagnum auriculatum				I		II	
Carex limosa						III	
Potamogeton polygonifolius						II	
Wet bare peat				I	I	V*	V*
Sphagnum cuspidatum		I			II		III*
Amorphous peat							II

Table 14c

Synoptic table for Loch Bad a'Choille. Constancy values are indicated in Roman numerals. High abundance is indicated by an asterisk.

cuspidatum, a good indicator of the transition from aquatic to terrestrial conditions in British mires. This upper limit for each site was taken as the factor necessary to correct the arbitrary height data to heights relative to the average water table.

Small-scale vegetation and surface patterns in Caithness and Sutherland

Tables 14a-e provide synoptic results for each of the five sites. Figures 87a-j present the data for each transect as a three-dimensional surface plot, generated by PC-Surfplot, and as a graph of ranges and medians for the vegetation noda. By using the combined information obtained from the synoptic tables and surface plots, the noda were provisionally assigned to associations described by Birse (1984) or Dierssen (1982). In the main surface plot in each figure, the noda or associations are mapped onto the 10 cm squares which make up the transect grid. The smaller surface plot shows the distinction between aquatic and terrestrial conditions within the transect. The graph of ranges and medians combines information from two of the five transects from each site, selected arbitrarily, and distinguishes between the height ranges for any nodum which occurs on both transects. The vertical scale for all such graphs has been standardised for the entire range of transects. The height range of one transect can therefore be compared directly with that of another, though the five height range graphs are also displayed together in Figure 88 to make comparison easier.

Dubh Lochs of Shielton

The most easterly of the sites, this shows a clear northern boreal influence in its vegetation. The

	F.1	F.2	F.3	F.4	F.5	F.6	F.7
Potentilla erecta							
Hypnum cupressiforme	IV		I				
Racomitrium lanuginosum	III*		I				
Cladonia impexa	V*	II	I				
Bare peat	III	I	II				
Pleurozium schreberi		I					
Calluna vulgaris	V*	IV	IV*		I		
Sphagnum rubellum	III*	V*	V*	III	I	I	
Sphagnum subnitens		II	I		I		
Myrica gale	II	II	II		I	I	
Erica tetralix	IV*	IV*	III		II		I
Odontoschisma sphagni		II	I		I		
Eriophorum vagmatum		I	I	II	I		
Drosera rotundifolia		IV	II	III	I		
Molinia caerulea	IV	II	III		II	I	I
Cladonia uncialis		I	I		I		
Sphagnum magellanicum		III	V*	IV	III		I
Narthecium ossifragum		II	V*		III		
Sphagnum tenellum		III	V*	II	IV*		
Cephalozia connivens					I		
Trichophorum cespitosum		I	II		II		
Pleurozia purpurea		I			III		
Sphagnum papillosum		II		V*	IV*	II	I
Eriophorum angustifolmm	III	III		III	IV*	IV*	I
Sphagnum compactum					I		
Rhynchospora alba		III		IV	IV*	III	I
Menyanthes trifoliata		II	II		II		II
Wet bare peat					I		
Drosera anglica		I			II	II	I
Sphagnum cuspidatum		I			IV*	V*	V*
Sphagnum auriculatum					I	III*	II
Open water					II	V*	
Carex limosa					I		II
Amorphous peat					I	II	V*
Molinia litter					I	IV	
Eleocharis multicaulis							II

Table 14d

Synoptic table for Blar nam Fear Mhora. Constancy values are indicated in Roman numerals. High abundance is indicated by an asterisk.

broad T2 high ridges are dominated by dwarf shrubs, though with a *Sphagnum* understorey, and a range of hypnoid mosses such as *Hylocomium splendens, Rhytidiadelphus loreus* and *Hypnum cupressiforme* can be found within the moss layer. *Arctostaphylos uva-ursi* occurs on high hummocks and across some high ridge areas towards the margin of the site. This species has been taken as an indicator of continental affiliations (Goode & Ratcliffe 1977), but, as it is regarded as a woodland species in Fennoscandia, the relationship is not entirely clear.

The lack of both *Molinia caerulea* and *Racomitrium lanuginosum* is an important feature, as is the presence of *Eleocharis multicaulis* in the Al hollows and deep A3/A4 pools. The site is one of the few for *Vaccinium microcarpum* in the two Districts.

The extreme height range of the site can be seen in Figures 87a-b, where the wide T2 ridges possess a relatively uniform vegetation cover and the deep watershed pools drop away with very little marginal vegetation.

Strathy River Bog

Described by Pearsall in 1956, this is one of the classic sites of British mire ecology. The small valleyside flow is dominated by crescentic hollows which are much shallower than the deep watershed pools of the Dubh Lochs of Shielton. Figure 87c illustrates a cross-section of such an A2 mud-bottom hollow, in contrast to an Al *Sphagnum* carpet, whereas Figure 87d demonstrates the gradual transition from T1 low ridge dominated by *Sphagnum papillosum* down to *S. cuspidatum* Al carpet. *AS. imbricatum* T3 hummock is illustrated in Figure 87c.

Arctostaphylos uva-ursi occurs in small amounts, but it is joined by the characteristic shrub of northern boreal mires, *Betula nana.* Here it is within the central part of its distribution. The site lies near the transition between the Erico-Sphagnetum magellanici and the Pleurozio-Ericetum tetralicis, indicated by the small amounts of *Racomitrium lanuginosum* and *Pleurozia purpurea* in the sward.

	AF.1	AF.2	AF.3	AF.4	AF.5	AF.6	AF.7	AF.8	AF.9
Hylocomium splendens	I								
Sphagnum fuscum	V*								
Pleurozium schreberi	II			I					
Empetrum nigrum	V*	V*	II	V*					
Eriophorum vaginatum	III	I	II		I	I			
Drosera rotundifolia	III		II		I	II			
Sphagnum subnitens			II						
Rhytidiadelphus loreus	I								
Erica tetralix	IV		III	III	III	II		I	
Hypnum cupressiforme	I		I	V*	I				
Racomitrium lanuginosum	I	V*	I		IV*	I			
Eriophorum angustifolium	II		III	III	III	III		I	
Cladonia uncialis			I		I	I			
Cladonia impexa	I		II		III	I			
Sphagnum rubellum			V*		II	III		I	
Bare peat			I	V*	IV*	I			
Calluna vulgaris	II		V*		IV*	IV*	I		
Carex pauciflora			I		I				
Trichophorum cespitosum	I		I	IV*	III	IV	I	IV*	I
Narthecium ossifragum	I		IV*	IV	V*	V*	I	III	I
Pleurozia purpurea					V*	II			
Sphagnum tenellum			III		II	IV		IV*	I
Mylia anomala					I	I			
Sphagnum papillosum			I		II	V*	I	II	
Drosera anglica					I	II	I	III	
Wet bare peat					I	I	V*		
Menyanthes trifoliata						I	I	I	I
Carex limosa						I	IV	I	I
Sphagnum cuspidatum					I	I	II	IV	III
Sphagnum auriculatum						I	III	I	I
Amorphous peat					I	II	V*	V*	
Open water									V*

Table 14e

Synoptic table for Allt an Fhaing. Constancy values are indicated in Roman numerals. High abundance is indicated by an asterisk.

Loch Bad a' Choille

This site is an example of the mire type identified as ladder fen and described in Chapter 9. The hollows are typical mud-bottom ones, with dominant bare peat and a scatter of aquatic *Sphagna,* but the slight minerotrophic element in the site is indicated by the presence of *Potamogeton polygonifolius.* Similarly, the ridges indicate an enhanced level of enrichment by the presence of *Carex dioica* and, to a lesser extent, C. *pauciflora, Molinia caerulea* and *Pinguicula vulgaris.*

The relative abundance *of Molinia, Pleurozia purpurea* and *Racomitrium lanuginosum* confirms the ridge communities as facies of the Pleurozio-Ericetum tetralicis, though some ladder fen ridges are more closely related to the Campylio-Caricetum dioicae.

The relatively small-scale relief, typically consisting of no more than T2, T1 and A2 (high ridge, low ridge and mud-bottom), is clearly seen on the surface plots and the graphs of height ranges (Figures 87e-f).

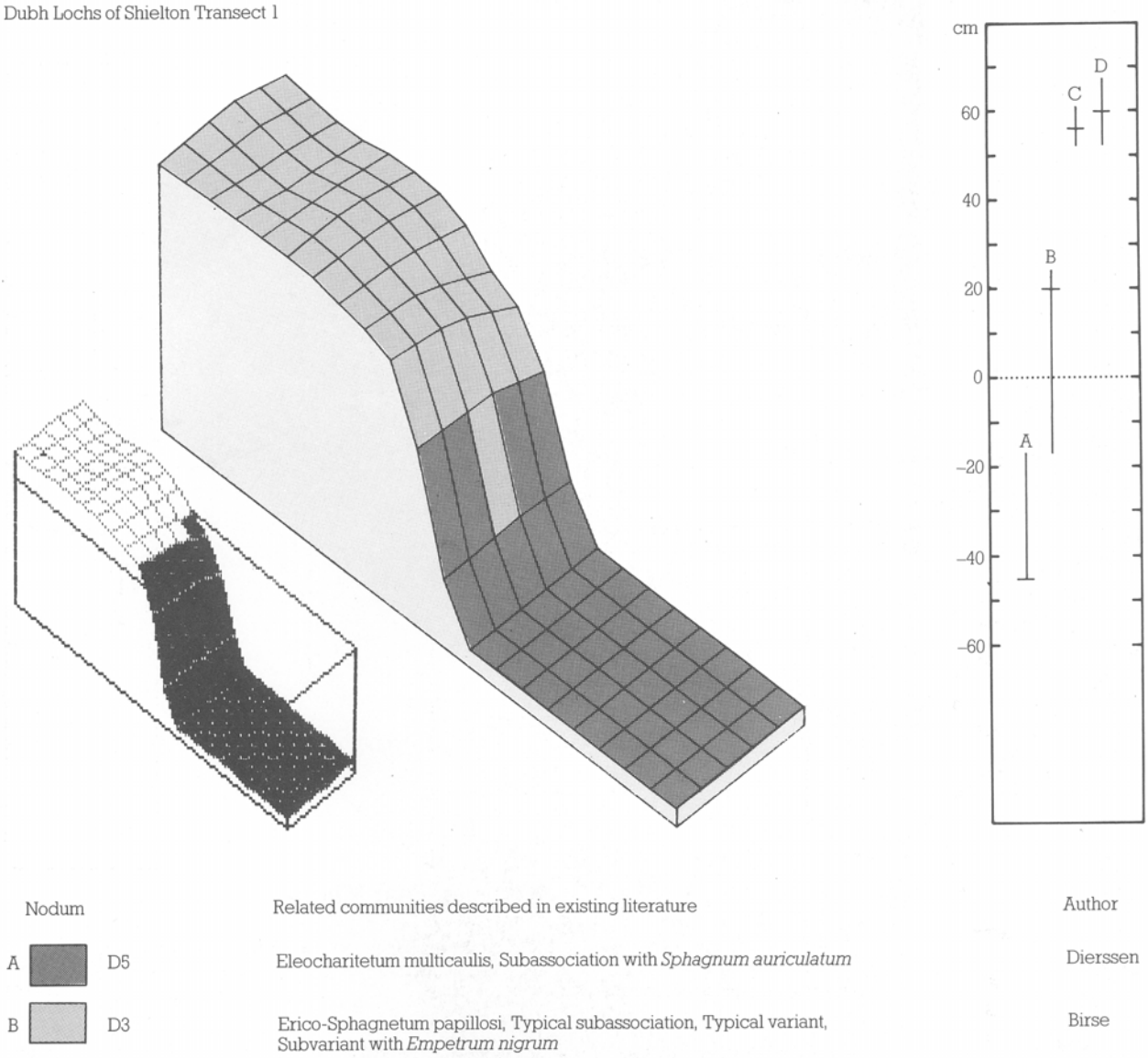
Blar nam Fear Mhora

This is the most westerly of the examples, lying within the line of the Moine Thrust mountains and 10 km east of Lochinver, a major west coast fishing port. The small-scale relief of this site is in complete contrast to the microtopography of the Dubh Lochs of Shielton, although the immediate appearance of many of the A2/A3 pools is very similar to that in parts of the Dubh Lochs. The wide, open water pools are in fact relatively shallow, as indicated by Figure 87h. The dense mixture of detritus and *Molinia* litter produces a matrix which, though not capable of supporting the weight of a man, can form a firm base into which species such as *Carex limosa, Eleocharis multicaulis* and *Rhynchospora alba* can root. This type of pool bottom is common in hyperoceanic areas, and the influence of accumulated *Molinia* litter within pools on the Silver Flowe is discussed by Goode(1970).

The presence of *Potentilla erecta, Molinia caerulea, Pleurozia purpurea* and *Rhynchospora alba,* together with hummocks of *Racomitrium*

Figure 87 Surface plots for sites listed in Tables 13a-e indicating - (a) distribution of individual vegetation associations within the 2 m x 50 cm transects, together with (b) the location of the average water table through the transect, and (c) the median and range of heights for each association. Associations which occur in two transects on the same site are indicated as separate records in the graph of heights (c). Surface and water table plots generated by Surfplot.

Figure 87a



lanuginosum not linked to erosion or damage, typifies the mire vegetation of western Sutherland, contrasting strongly with that of eastern Caithness. Indeed, the vegetation is more closely related to that found in the Hebrides (Goode & Lindsay 1979; Lindsay *et al.* 1983) or western Ireland (Boatman 1960).

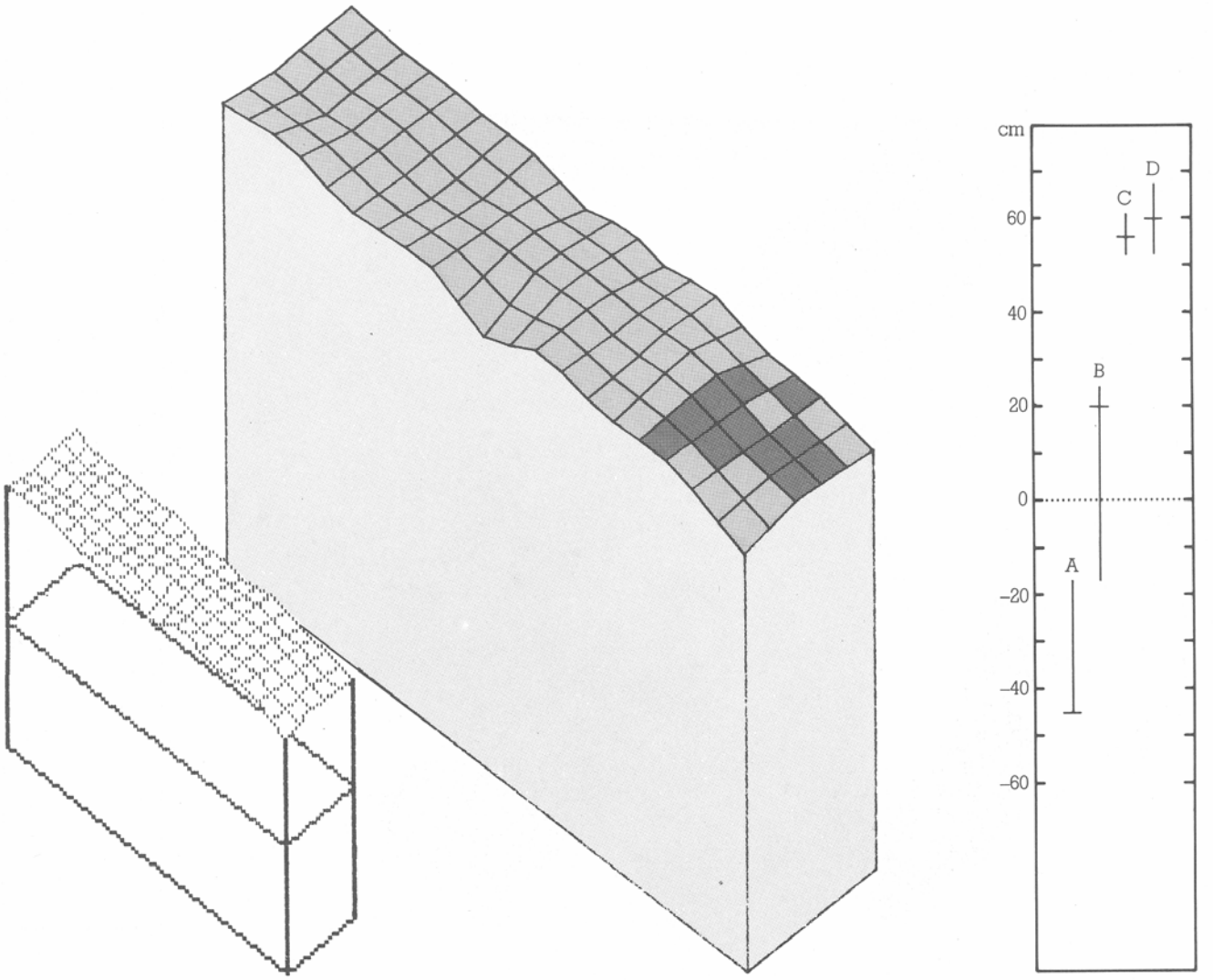
Allt an Fhaing

This site is included to demonstrate some of the effects of damage and erosion on vegetation and microtopography. It lies on the flood plain of the Allt an Fhaing and has a surface pattern consisting largely of erosion features, though some small areas remain relatively intact.

The highest level in the pattern is occupied by *Sphagnum fuscum* hummocks. Though regarded as important features because *S. fuscum* is fast becoming an endangered species in Britain, such hummocks are typically the slowest part of the original surface pattern to be lost when erosion produces a lowering of the average water table. This is because hummock species are more adapted to long drought periods and can therefore tolerate the effects of drawdown in the water table more easily

Figure 87b

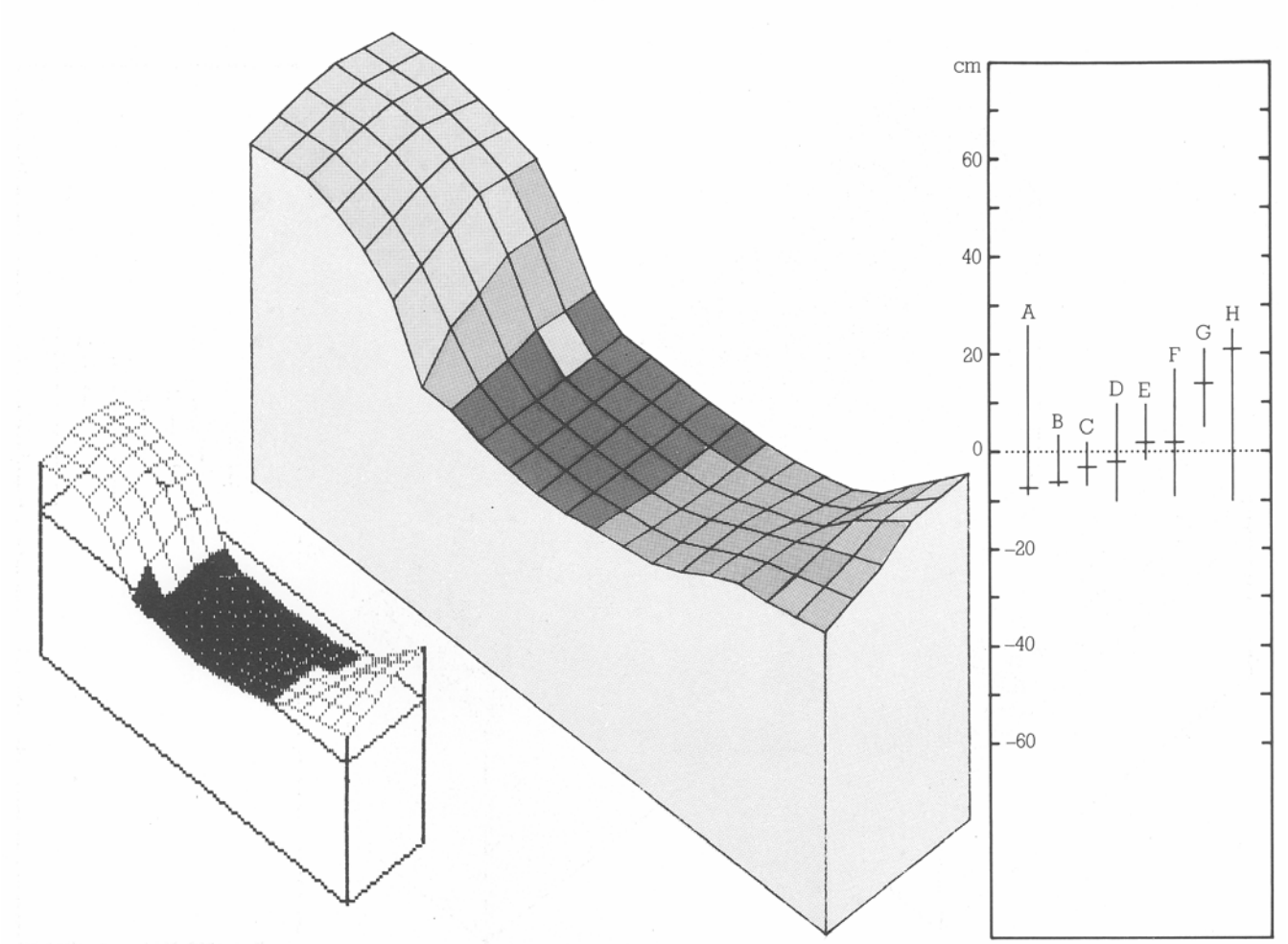
Dubh Lochs of Shielton Transect 4



Nodum		Related communities described in existing literature	Author
C	D3	Erico-Sphagnetum papillosi, Typical subassociation, Typical variant, Subvariant with *Empetrum nigrum*	Birse
D	D1	Erico-Sphagnetum papillosi, Typical subassociation, Typical variant, Typical subvariant	Birse

Figure 87c

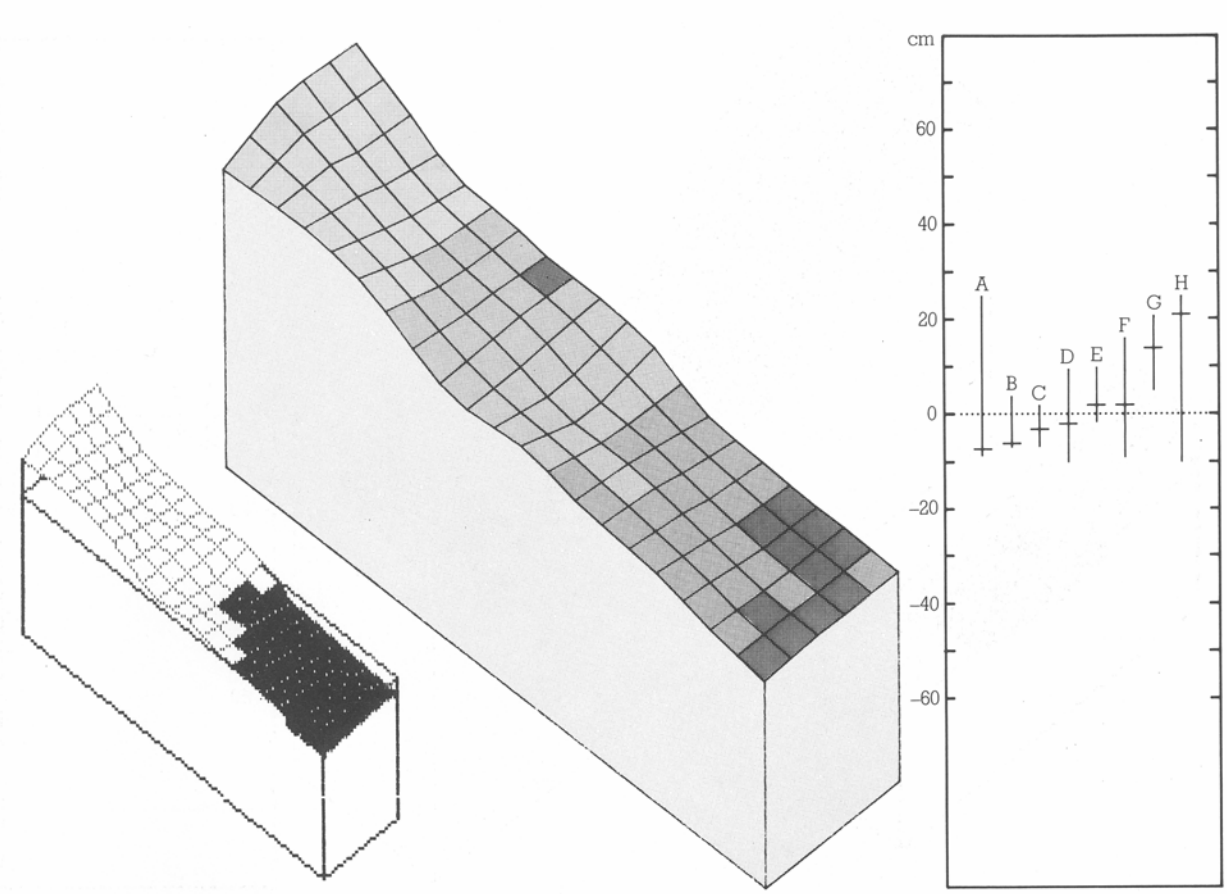
Strathy Bog Transect 2



Nodum		Related communities described in existing literature	Author
A	S6	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
D	S5	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
F	S4	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
H	S1	Erico-Sphagnetum magellanici, Typical subassociation, Phase with *Sphagnum imbricatum*, Typical variant	Dierssen

Figure 87d

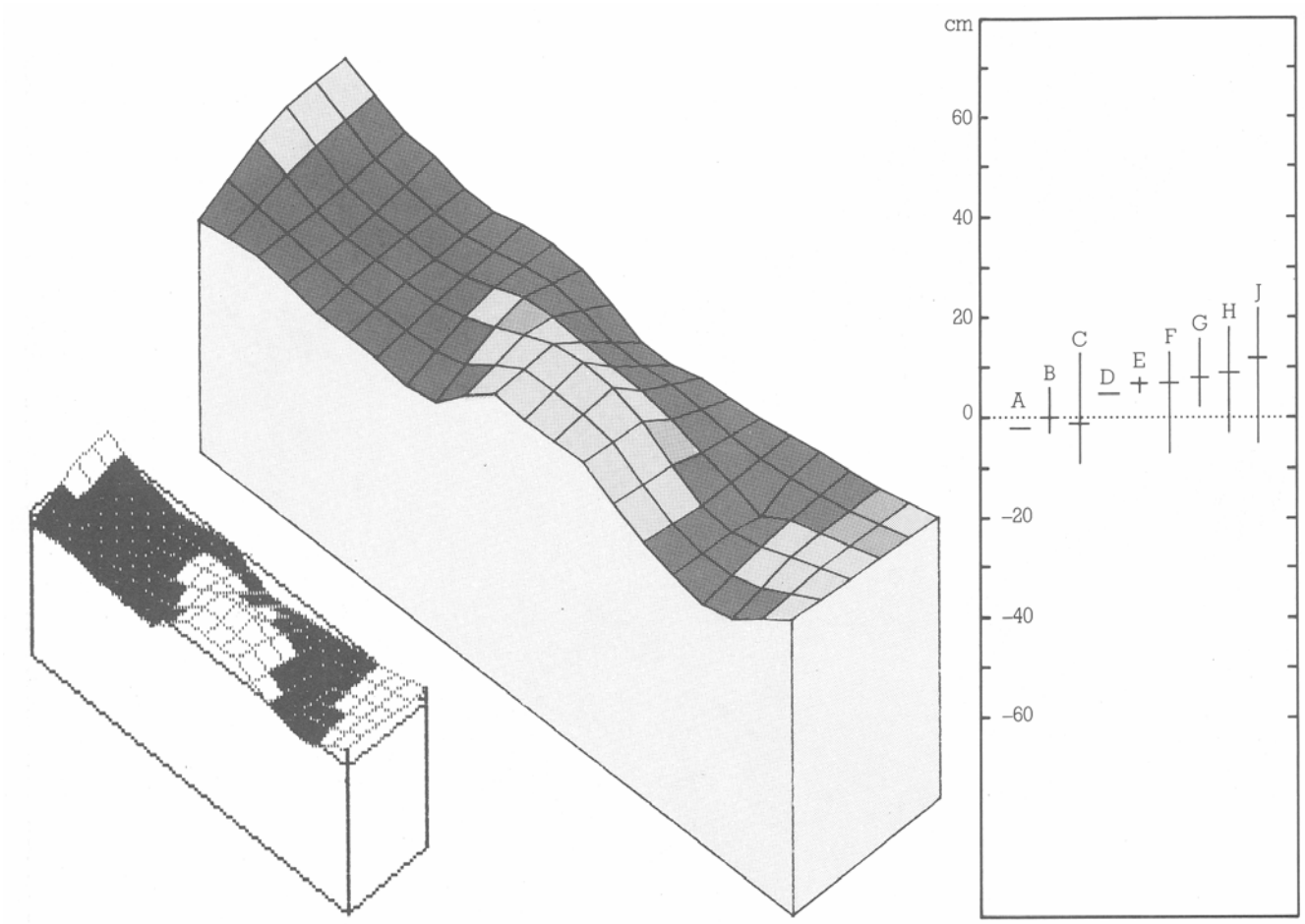
Strathy Bog Transect 4



Nodum		Related communities described in existing literature	Author
B	S6	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
C	S5	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
E	S4	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
G	S3	Erico-Sphagnetum magellanici, Subassociation with *Cladonia uncialis*, Typical variant	Dierssen

Figure 87e

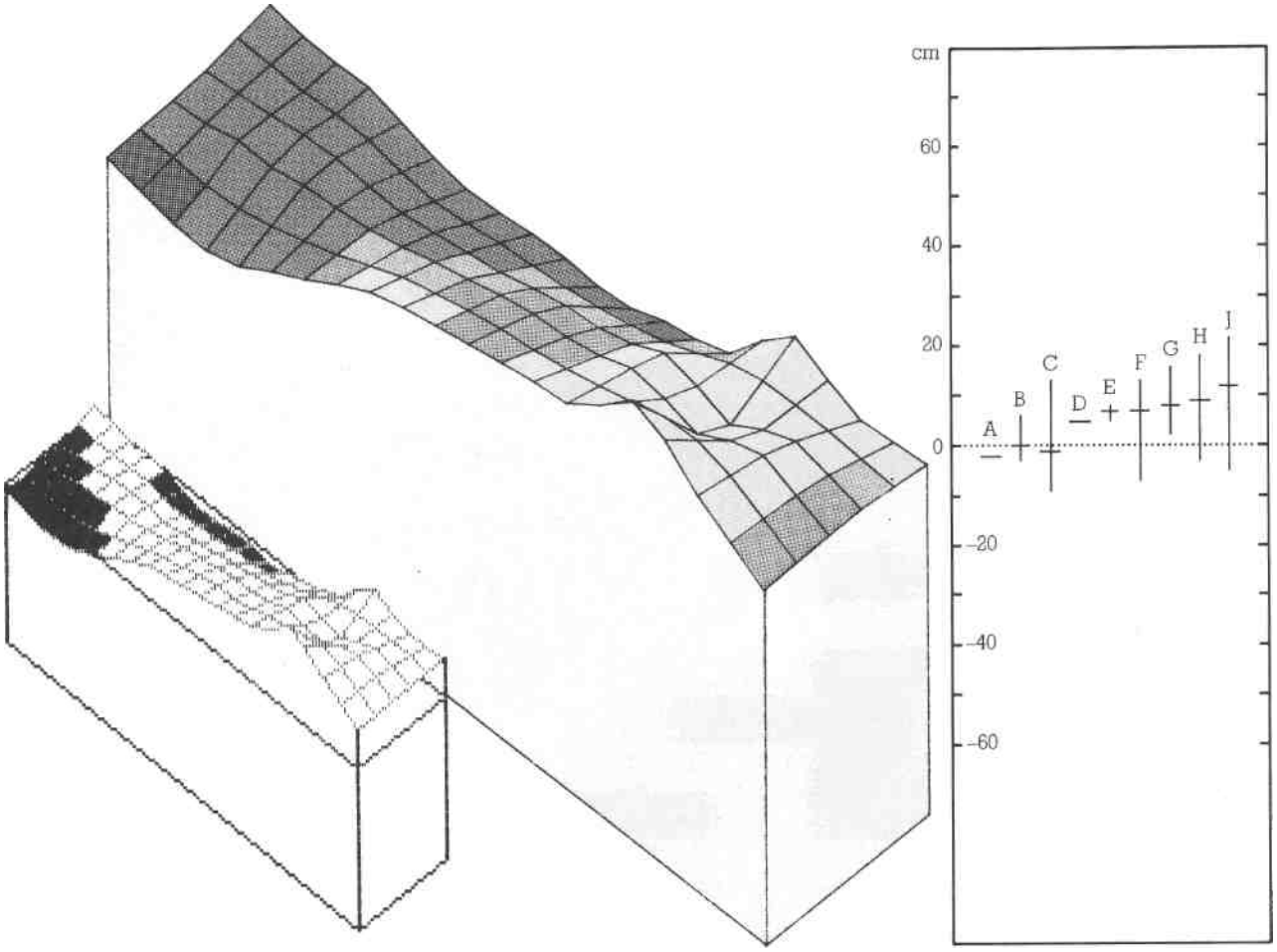
Loch Bad a'Choille Transect 1



Nodum		Related communities described in existing literature	Author
B	C6	Caricetum limosae, Typical subassociation	Dierssen
D	C7	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
E	C3	Erico-Sphagnetum magellanici, Subassociation with *Cladonia uncialis*, Phase with *Racomitrium lanuginosum*	Dierssen
G	C4	Pleurozio-Ericetum tetralicis, Facies with *Molinia caerulea*	Dierssen

Figure 87f

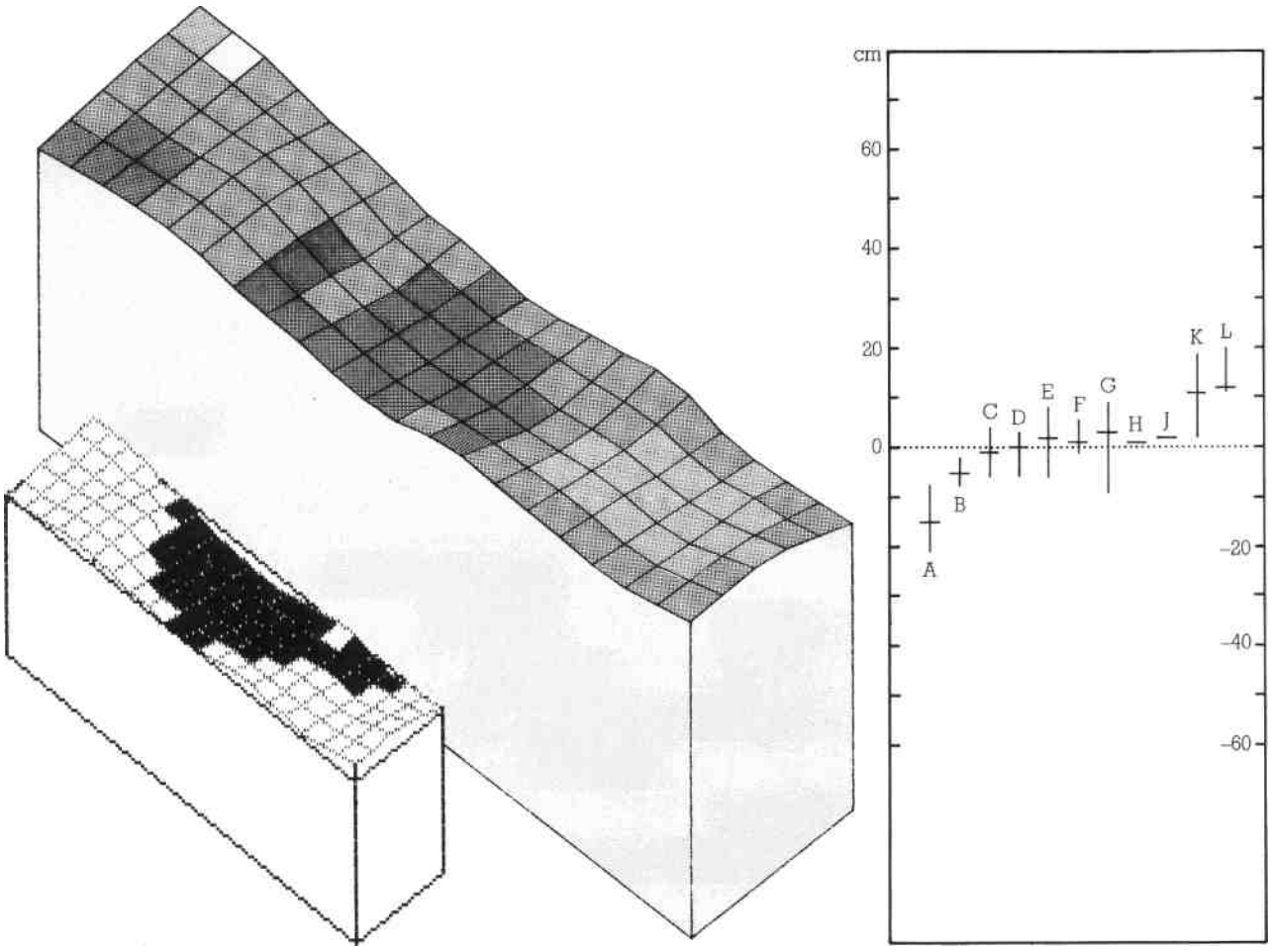
Loch Bad a'Choille Transect 4



Nodum		Related communities described in existing literature	Author
A	C6	Caricetum limosae, Typical subassociation	Dierssen
C	C7	*Eriophorum angustifolium*, Subassociation with *Sphagnum cuspidatum*	Dierssen
F	C5	Erico-Sphagnetum papillosi, Typical subassociation, Variant with *Molinia caerulea*, Typical subvariant	Birse
H	C2	Erico-Sphagnetum papillosi, Typical subassociation, Variant with *Molinia caerulea*, Typical subvariant	Birse
J	C1	Erico-Sphagnetum papillosi, Typical subassociation, Variant with *Molinia caerulea*, Typical subvariant	Birse

Figure 87g

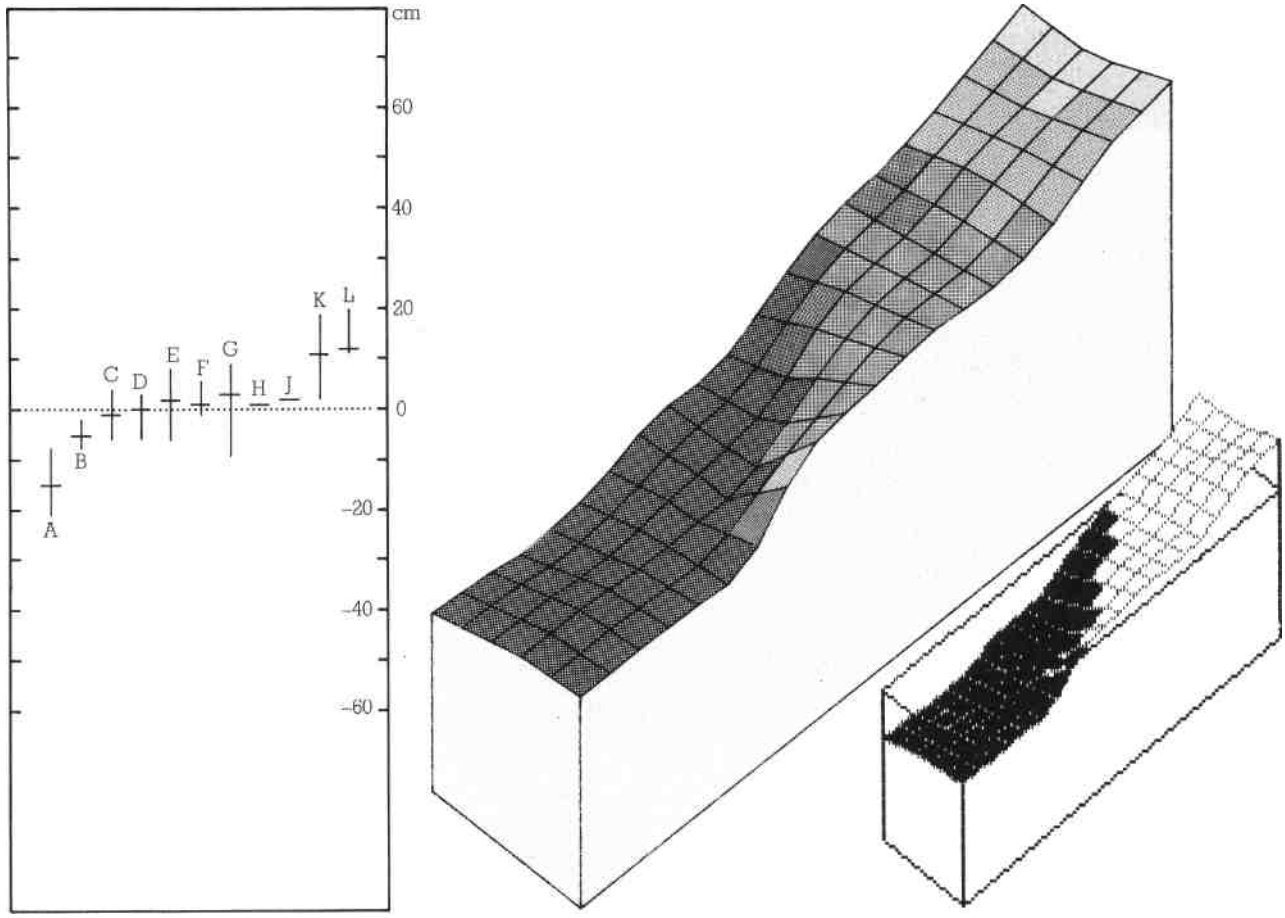
Blar nam Fear Mhora Transect 1



Nodum		Related communities described in existing literature	Author
C	F6	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum auriculatum*, Variant with *Rhynchospora alba*	Dierssen
E	F5	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum tenellum*, Variant with *Sphagnum papillosum*	Dierssen
F	F4	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum tenellum*, Variant with *Sphagnum papillosum*	Dierssen
H	F3	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum tenellum*, Variant with *Sphagnum papillosum*	Dierssen
J	F2	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum papillosum*, Variant with *Sphagnum papillosum*, Facies with *Rhynchospora alba*	Dierssen

Figure 87h

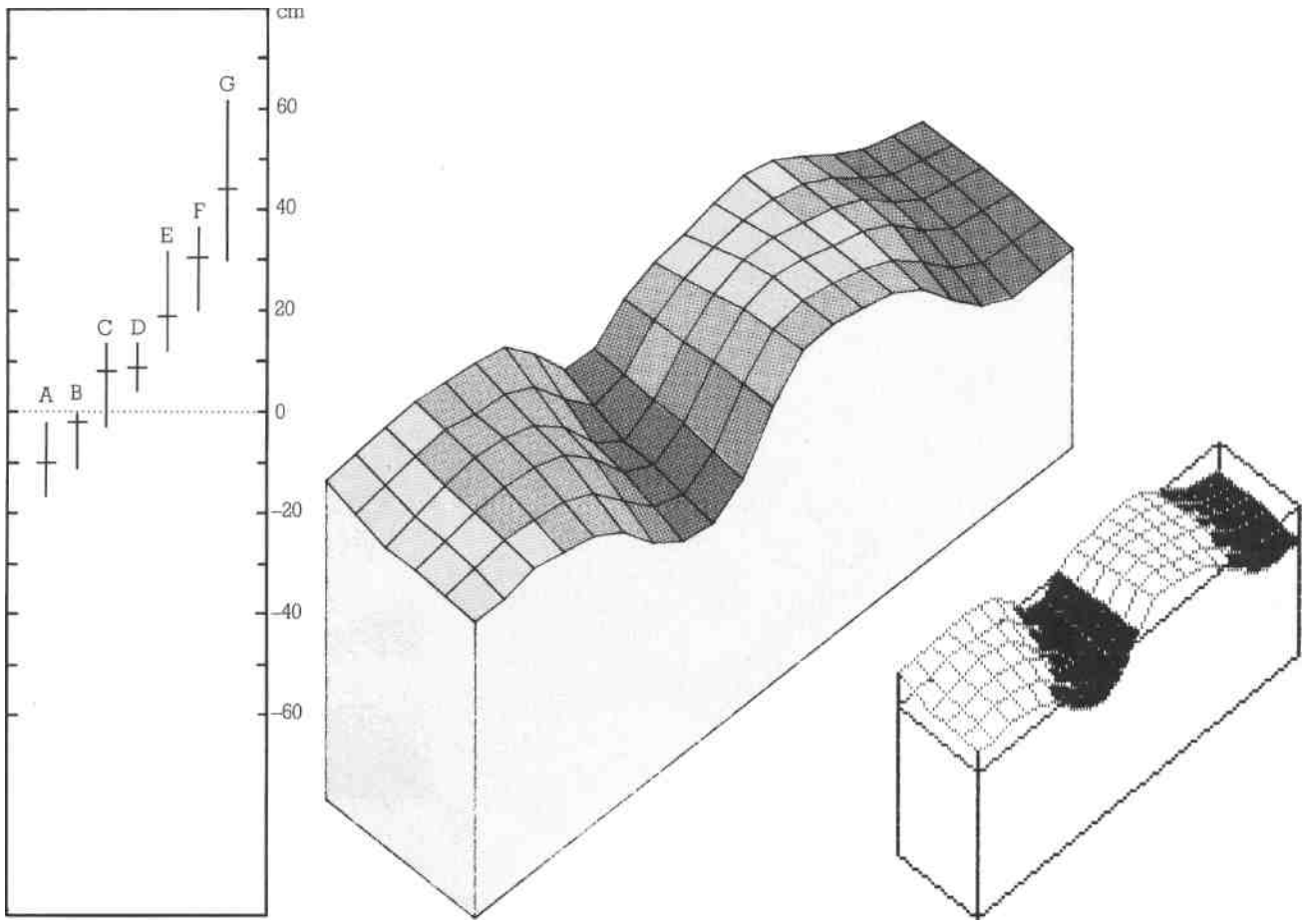
Blar nam Fear Mhora Transect 3



Nodum		Related communities described in existing literature	Author
A	F7	Eleocharitetum multicaulis, Subassociation with *Sphagnum auriculatum*	Dierssen
B	F6	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum auriculatum*, Variant with *Rhynchospora alba*	Dierssen
D	F5	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum tenellum*, Variant with *Sphagnum papillosum*	Dierssen
G	F4	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum tenellum*, Variant with *Sphagnum papillosum*	Dierssen
K	F2	Sphagno tenelli-Rhynchosporetum albae, Subassociation with *Sphagnum papillosum*, Variant with *Sphagnum papillosum,* Facies with *Rhynchospora alba*	Dierssen
L	F1	Pleurozio-Ericetum tetralicis, Subassociation with *Racomitrium lanuginosum*, Facies with *Molinia caerulea*	Dierssen

Figure 87i

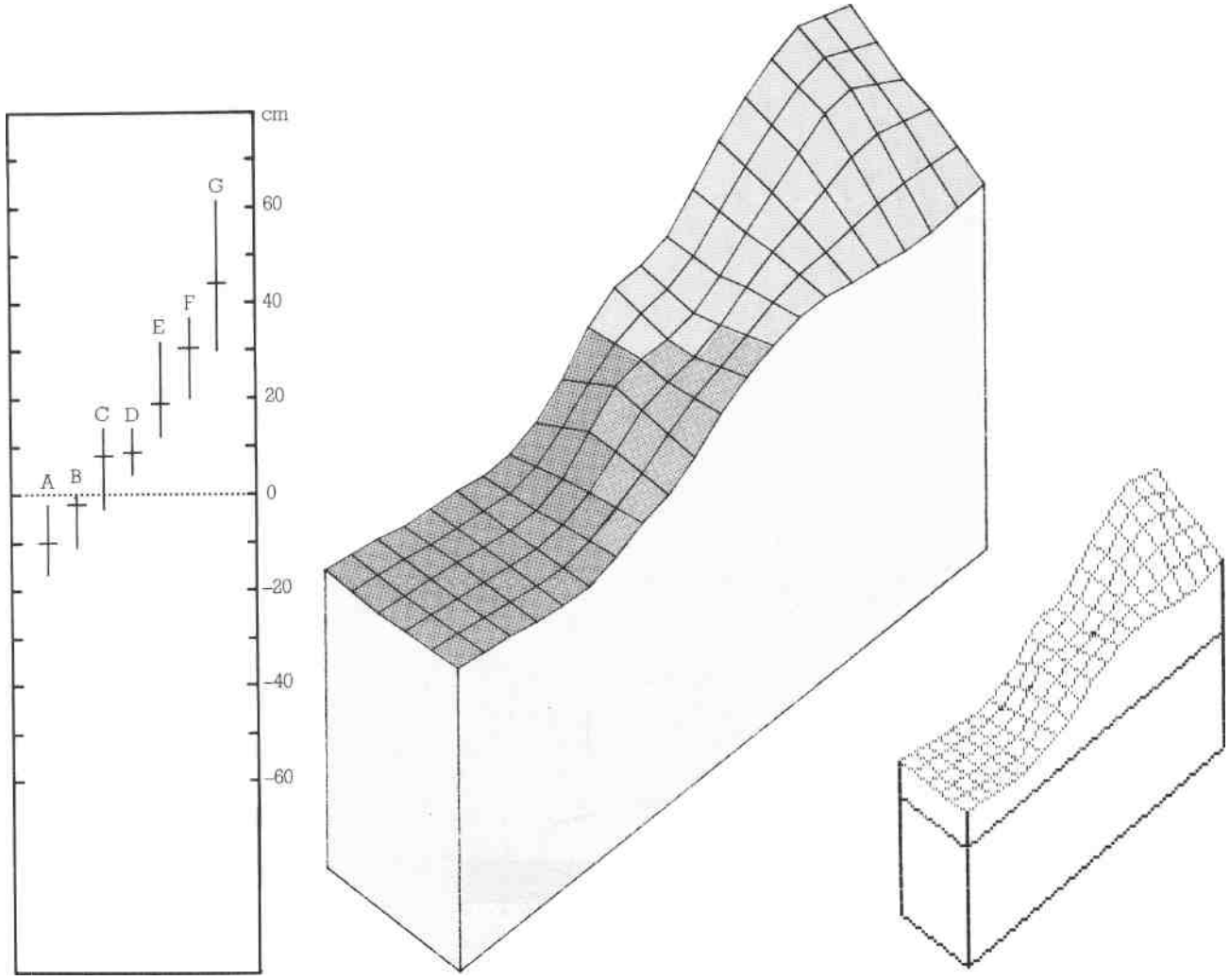
Allt an Fhaing Transect 1



	Nodum		Related communities described in existing literature	Author
A		AF9	*Eriophorum angustifolium**, Subassociation with *Sphagnum cuspidatum* (* AF9 lacks *Eriophorum angustifolium*)	Dierssen
B		AF8	Sphagno tenelli-Rhynchosporetum albae*, Subassociation with *Sphagnum tenellum*, Variant with *Sphagnum papillosum* (* AF8 lacks *Rhynchospora alba*)	Dierssen
C		AF6	Narthecia-Sphagnetum papillosi, Typical subassociation, Typical variant	Dierssen
D		AF5	Pleurozio-Ericetum tetralicis, *Molinia caerulea* facies*, Subassociation with *Racomitrium lanuginosum* (*AF5 lacks *Molinia caerulea*)	Dierssen

Figure 87j

Allt an Fhaing Transect 4



Nodum		Related communities described in existing literature	Author
E	AF4	Empetro-Eriophoretum*, Typical subassociation (*AF4 lacks *Rubus chamaemorus*)	Dierssen
F	AF2	Empetro-Eriophoretum*, Subassociation with *Cladonia arbuscula***, Variant with *Racomitrium lanuginosum* (*AF2 lacks *Rubus chamaemorus*, **AF2 lacks *Cladonia arbuscula*)	Dierssen
G	AF1	Empetro-Sphagnetum fusci, Subassociation with *Sphagnum fuscum*, Typical formation with *Calluna vulgaris*	Dierssen

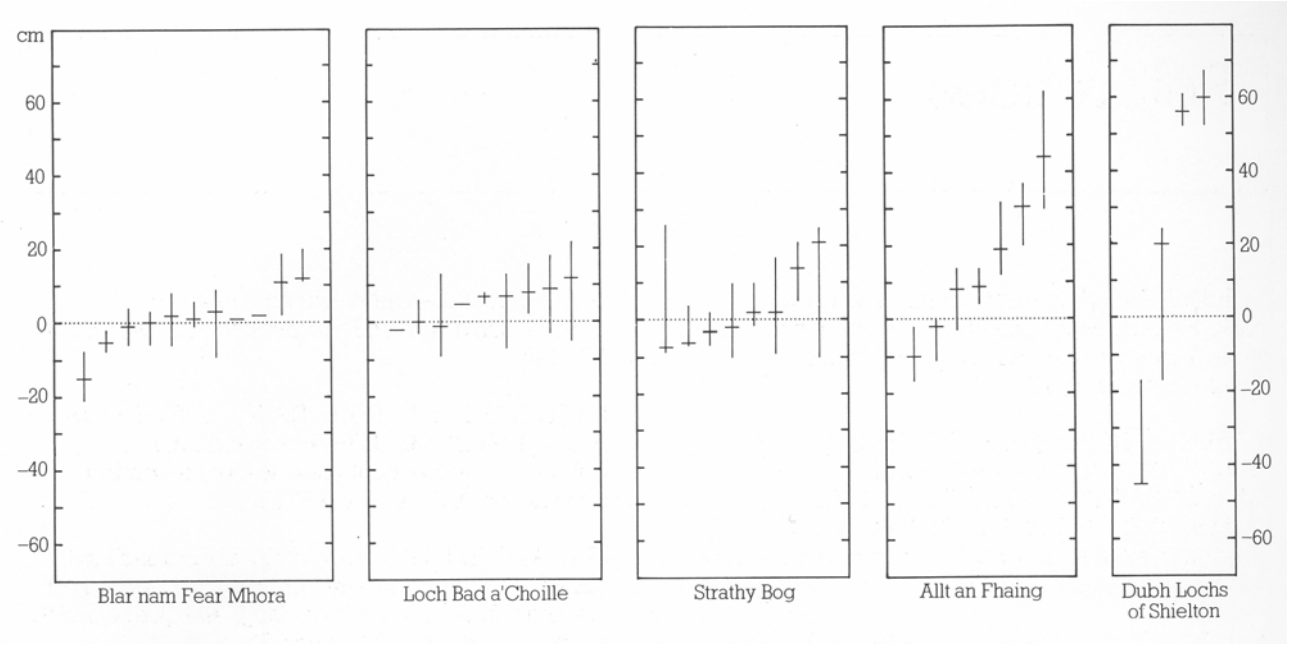


Figure 88 Range of heights and modes displayed by all the noda illustrated in Figures 87a-j, to emphasise the variation in height ranges between sites. Noda which occur in two transacts on one site are displayed as separate records for each transect.

than species typical of wetter levels in the microtopography (see Chapter 5). In addition, the extremely fibrous nature of hummocks makes them highly resistant to erosive scouring (Hobbs 1986).

Racomitrium lanuginosum is present as hummocks and within the T1/T2 ridge, but its relative abundance on this site is more an indication of damage than a reflection of climate. Indeed the level of damage can be seen from the extensive occurrence of noda AF1 and AF2 throughout the T2 zone. Once down from the hummocks, the general mire surface is dominated by these two noda, which are characterised by abundant bare peat and *Trichophorum cespitosum*.

The T1 zone (low ridge) is reduced to a small fringe of vegetation dominated by *Sphagnum tenellum* around the margins of eroding hollows and pools. *S. tenellum* is characteristic of damaged areas in the west. It acts as 'scar tissue' on ground which has been burnt or drained and then resoaked (Lindsay unpublished) and forms a distinct association with *S. cuspidatum* on ground which is eroding but has not reached the deep gully stage. This type of ground has been termed "microbroken" during the survey, because it indicates a microtopography which is broken into an anastomosing network enclosing small ridge-islands but which has not developed the deep gullies and hags of the more typical dendritic erosion complex. The channels of such microbroken ground are characteristically dominated by a *Sphagnum tenellumlS. cuspidatum* mixture which is illustrated by noda AF8 and AF9; the form of this microtopography is well illustrated by Figure 87i.

The wide range of heights displayed by the microtopography at Allt an Fhaing is typical of an eroding surface, where the ridge zone is left high above the water table and hummocks become hags.

References

AARIO, L, 1932, Pflanzentopographische und paläogeographische Mooruntersuchungen in N-Satakunta, *Institutum Forestale Fenniae. Communicationes, 17.*

ACADEMY OF SCIENCES OF THE U.S.S.R., & CHIEF DIRECTORATE OF GEODESY AND CARTOGRAPHY, STATE GEOLOGICAL COMMITTEE OF THE U.S.S.R, 1964. *Fiziko-geograficheskU Atlas Mira. [Physico-geographical Atlas of the World].* Moscow,

ALABASTER, J,S,, & LLOYD, R,, eds, 1980, *Water Quality Criteria for Freshwater Fish.* London, Butterworth Scientific, for F.A.O,

ALLEN, S.E. 1964. Chemical aspects of heather burning. *Journal of Applied Ecology, 1,* 347-367.

ANGUS, S. 1986, The peatland habitat resource of Sutherland and Caithness in relation to forestry, Inverness, Nature Conservancy Council, North-West Scotland Region (unpublished report).

ARMSTRONG, W,, & BOATMAN, D.J. 1966. Some field observations relating the growth of bog plants to conditions of soil aeration. *Journal of Ecology 55,* 101-110.

AUER, V. 1933. Verschiebungen der Wald- und Steppengebiete Feuerlands in postglazialer Zeit. *Acta Geographica, Helsinki,* 5(2), 1-313.

AUER, V. 1965. The Pleistocene of Fuego-Patagonia. Part IV: Bog profiles. *Annales Academiae Scientiarum Fennicae, A, 80,* 1-160.

BAINBRIDGE, LP., MINNS, D.W., HOUSDEN, S.D., & LANCE, AN 1987. *Forestry in the Flows of Caithness and Sutherland.* Sandy, Royal Society for the Protection of Birds.

BAKKER, E.M. van Z., Sr,, WINTERBOTTOM, J.M., & DYER, R.A., eds. 1971. *Marion and Prince Edward Islands; report on the South African Biological and Zoological Expedition, 1965-66.* Cape Town, Balkema.

BANNER, A, POJAR, J., & TROWBRIDGE, R. 1986. *Representative Wetland Types of the Northern Part of the Pacific Oceanic Wetland Region.* Province of British Columbia, Ministry of Forests.

BARBER, K. E. 1981. *Peat Stratigraphy and Climatic Change.* Rotterdam, Balkema.

BATTARBEE, R.W., APPLEBY, P.G, ODELL, K,, & FLOWER, R.J. 1985.^{210}Pb dating of Scottish lake sediments, afforestation and accelerated soil erosion. *Earth Surface Processes and Landforms, 10,* 137-142.

BATTARBEE, R.W., FLOWER, R.J., STEVENSON, AC, & RIPPEY, B. 1985. Lake acidification in Galloway: a palaeoecological test of competing hypotheses. *Nature, 314,* 350-352.

BELLAMY, D.J. 1968. An ecological approach to the classification of European mires. *In: Proceedings of the Third International Peat Congress, Quebec, 1968,* ed. by C. Lafleur and J. Butler, 74-79.

BELLAMY, D.J., & BELLAMY, R. 1966. An ecological approach to the classification of the lowland mires of Ireland. *Royal Irish Academy. Proceedings, 65B,* 237-251.

BELLAMY, D.J., &PRITCHARD, T. 1973. Project 'Telma': a scientific framework for conserving the world's peatlands. *Biological Conservation, 5,* 33-40.

BERGKVIST, B. 1986. Leaching of metals from a spruce forest soil as influenced by experimental acidification. *Water, Air, and Soil Pollution, 31,* 901-916.

BIBBY, J.S., DOUGLAS, H.A, THOMASSON, A.J., & ROBERTSON, J.S. 1982. *Land Capability Classification for Agriculture.* Aberdeen, Macaulay Institute for Soil Research.

BIRKS, H.H. 1970. Studies in the vegetational history of Scotland. I. A pollen diagram from Abernethy Forest, Inverness-shire. *Journal of Ecology, 58,* 827-846.

BIRKS, H. H. 1972. Studies in the vegetational history of Scotland. II. Two pollen diagrams from the Galloway Hills, Kirkcudbrightshire. *Journal of Ecology, 60,* 183-217.

BIRKS, H.H. 1975. Studies in the vegetational history of Scotland. IV. Pine stumps in Scottish blanket peats. *Royal Society. Philosophical Transactions, B, 270,* 181-226.

BIRKS, H.J.B. 1973. *Past and Present Vegetation of the Isle of Skye - a Palaeoecological Study.* Cambridge, Cambridge University Press.

BIRKS, H.J.B. in press. Long-term change in the British uplands. *In: Ecological Change in the Uplands,* ed. by M. Usher and D.B.A. Thompson. Oxford, Blackwell Scientific.

BIRNIE, J.F. 1984. Trees and shrubs in the Shetland

Islands: evidence for a postglacial climatic optimum? *In: Climatic Changes on a Yearly to Millennial Basis,* ed. by N.A. Morner and W. Karlen, 155-161. Dordrecht, Netherlands, Reidel.

BIRSE, E.L. 1971. *Assessment of Climatic Conditions in Scotland. 3. The Bioclimatic Sub-regions.* Aberdeen, Macaulay Institute for Soil Research.

BIRSE, E.L. 1980. *Plant Communities of Scotland. A Preliminary Phytocoenonia.* Aberdeen, Macaulay Institute for Soil Research (Soil Survey of Scotland Bulletin No. 4).

BIRSE, E.L. 1984. *The Phytocoenonia of Scotland. Additions and Revision.* Aberdeen, Macaulay Institute for Soil Research (Soil Survey of Scotland Bulletin No. 5).

BIRSE, E.L., &DRY, F.T. 1970. *Assessment of Climatic Conditions in Scotland. 1. Based on Accumulated Temperature and Potential Water Deficit.* Aberdeen, Macaulay Institute for Soil Research.

BIRSE, E.L., & ROBERTSON, L. 1970. *Assessment of Climatic Conditions in Scotland. 2. Based on Exposure and Accumulated Frost.* Aberdeen, Macaulay Institute for Soil Research.

BLYTT, A. 1876. *Essay on the Immigration of the Norwegian Flora during alternating Rainy and Dry Periods.* Christiana, Cammermeyer.

BOATMAN, D.J. 1960. The relationships of some bog communities in western Galway. *Royal Irish Academy. Proceedings, 6IB,* 141-166.

BOATMAN, D.J. 1983. The Silver Flowe National Nature Reserve, Galloway, Scotland. *Journal of Biogeography 10,* 163-274.

BOATMAN, D.J., & ARMSTRONG, W. 1968. A bog type in north-west Sutherland. *Journal of Ecology 56,* 129-141.

BOATMAN, D.J., GOODE, D.A., & HULME, P.D. 1981. The Silver Flowe. III. Pattern development on Long Loch B and Craigeazle mires. *Journal of Ecology 69,* 897-918.

BOATMAN, D.J., & TOMLINSON, R.W. 1973. The Silver Flowe. I. Some structural and hydrological features of Brishie Bog and their bearing on pool formation. *Journal of Ecology 61,* 653-666.

BOELTER, D.H. 1972. Water table drawdown around an open ditch in organic soils. *Journal of Hydrology 15,* 329-340.

BOTCH, M.S., &MASING, V.V. 1983. Mire ecosystems in the U.S.S.R. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A.J. P. Gore, 95-152. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

BOWER, M.M. 1962. The cause of erosion in blanket peat bogs: a review of recent work in the southern Pennines. *Scottish Geographical Magazine, 78,* 33-43.

BOWLER, M., & BRADSHAW, R. 1985. Recent accumulation and erosion of blanket peat in the Wicklow Mountains, Ireland. *New Phytologist, 101,* 543-550.

BRAGG, O.M. 1982. The acrotelm of Dun Moss. PhD thesis, University of Dundee.

BRIMBLECOMBE, P., DAVIES, T., & TRANTER, M. 1986. Nineteenth-century black Scottish showers. *Atmospheric Environment, 20,* 1053-1057.

BROWN, R.J.E. 1983. Effects of fire on the permafrost ground thermal regime. *In: The Role of Fire m Northern Circumpolar Ecosystems,* ed. by R.W. Wein and D.A. MacLean, 97-110. Chichester, Wiley.

BURKE, W. 1975. Fertiliser and other chemical losses in drainage water from blanket bog. *Irish Journal of Agricultural Research, 14,* 163-178.

CAJANDER, A.K. 1913. Studien über die Moore Finnlands. *Acta Forestalia Fennica, 2,* 1-208.

CAMPBELL, E.O. 1983. Mires of Australasia. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A.J.P. Gore, 153-180. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

CHAPMAN, S.B. 1964. The ecology of Coom Rigg Moss, Northumberland. I. Stratigraphy and present vegetation. *Journal of Ecology, 52,* 299-313.

CHAPMAN, S.B., &ROSE, R.J. 1986. *An assessment of changes in the vegetation at Coom Rigg Moss National Nature Reserve within the period 1958-86.* Wareham, Institute of Terrestrial Ecology, Furzebrook Experimental Station (contract report to NCQITE Project 1092).

CHARMAN, D.J. 1986. The influence of area, habitat diversity and isolation period on species numbers of the Border Mires of Northumberland. BSc thesis, University of Newcastle upon Tyne.

CHARTER, E. 1985a. *A survey of some peatland sites in Sutherland.* Edinburgh, Nature Conservancy Council, Scottish Field Survey Unit (SFSU Report No. S20).

CHARTER, E. 1985b. *A survey of some peatland sites in Caithness.* Edinburgh, Nature Conservancy Council, Scottish Field Survey Unit (SFSU Report No. S24).

CHILDS, E.C. 1969. *An Introduction to the Physical Basis of Soil Water Phenomena.* London, Wiley.

CHISTJAKOV, V.I., KUPRIJANOV, A.I., GORSHKOV, V.V., & ARTSYBASHEV, E.S. 1983. Measures for fire-prevention on peat deposits.

In: The Role of Fire in Northern Circumpolar Ecosystems, ed. by R. W, Wein and D.A. MacLean, 259-271. Chichester, Wiley.

CLAPHAM, A.R., TUTIN, T.G., & WARBURG, E.F. 1962. *Flora of the British Isles.* 2nd ed. Cambridge, Cambridge University Press.

CLYMO, R.S. 1967. Control of cation concentrations, and in particular of pH, in *Sphagnum* dominated communities. *In: Chemical Environment in the Aquatic Habitat,* ed. by H.L. Golterman and R.S. Clymo, 273-284. Amsterdam, North-Holland Publishing Company.

CLYMO, R.S. 1983. Peat. *In: Mires: Swamp, Bog Fen and Moor General Studies,* ed. by A.J. P. Gore, 159-224. Amsterdam, Elsevier Scientific (Ecosystems of the World 4A).

CLYMO, R.S. 1984. The limits to peat bog growth. *Royal Society. Philosophical Transactions, B, 303,* 605-654.

CLYMO, R.S., &DUCKETT, J.G. 1986. Regeneration of *Sphagnum. New Phytologist, 102,* 589-614.

CLYMO, R.S., &HAYWARD, P.M. 1982. The ecology of *Sphagnum. In: Bryophyte Ecology,* ed. by A.J. E. Smith, 229-291. Newton Abbot, David and Charles.

CONOLLY, A.P., & DAHL, E. 1970. Maximum summer temperature in relation to the modern and Quaternary distributions of certain arctic-montane species in the British Isles. *In: Studies in the Vegetational History of the British Isles,* ed. by D. Walker and R.G. West, 159-224. London, Cambridge University Press.

CONWAY, V.M. 1949. Ringinglow Bog, near Sheffield. II. The present surface. *Journal of Ecology, 37,* 148-170.

CONWAY, V.M. 1954. Stratigraphy and pollen analysis of southern Pennine blanket peats. *Journal of Ecology, 42,* 117-147.

CONWAY, V.M., & MILLAR, A. 1960. The hydrology of some small peat-covered catchments in the northern Pennines. *Institution of Water Engineers. Journal, 14,* 415-424.

COULSON, J.C., & BUTTERFIELD, J.E. 1978. An investigation of the biotic factors determining the rates of plant decomposition on blanket bog. *Journal of Ecology 66,* 631-650.

COUNCIL OF EUROPE. 1983. *List of rare, threatened and endemic plants in Europe.* Strasbourg, Council of Europe (Nature and Environment Series, No. 27).

COWARDIN, L.M., CARTER, V., COLET, F.C, & LaROE, E.T. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish and Wildlife Service.

COY, J.S. 1979. Forestry Commission aerial application of fertilisers: effects on water quality. Dumfries, Solway River Purification Board (unpublished report).

CRAMPTON, C.B. 1911. *The Vegetation of Caithness considered in relation to the Geology.* Edinburgh, Committee for the Survey and Study of British Vegetation.

CRESSER, M., & EDWARDS, A. 1987. *Acidification of Fresh Waters.* Cambridge, Cambridge University Press.

CROMERTIE, George, Earl of. 1711. An account of the mosses in Scotland, *Royal Society. Philosophical Transactions, 27,* 296-301.

CUMMINS, C.P. 1986. Effects of aluminium and low pH on growth and development in *Rana temporaria* tadpoles. *Oecologia, 69,* 248-252.

CUTTLE, S.P. 1983. Chemical properties of upland peats influencing the retention of phosphate and *potassium. Journal of Soil Science, 34,* 75-82.

DANIELS, R.E. 1978. Floristic analyses of British mires and mire communities. *Journal of Ecology, 66,* 773-802.

DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND. 1965. *Scottish Peat Surveys. Vol. 2. Western Highlands and Islands.* Edinburgh, H.M.S.O.

DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND. 1968. *Scottish Peat Surveys. Vol. 4. Caithness, Shetland and Orkney.* Edinburgh, H.M.S.O.

DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND. 1977. *A Guide to Good Muirburn Practice.* Edinburgh, H.M.S.O.

DEPARTMENT OF ENERGY, MINES AND RESOURCES, CANADA. 1986. Canada. Wetland Regions. *In: The National Atlas of Canada.* 5th ed. Ottawa, Canada Map Office.

DICKINSON, C.H. 1983. Micro-organisms in peatlands. *In: Mires: Swamp, Bog, Fen and Moor. General Studies,* ed. by A.J. P. Gore, 225-245. Amsterdam, Elsevier (Ecosystems of the World 4A).

DIERSSEN, K. 1982. *Die wichtigsten Pflanzengesellschaften der Moore NW-Europas. [The Major Plant Communities of North-west European Mires].* Geneva, Conservatoire et Jardin Botaniques.

DRAKEFORD, T. 1979. Report of survey of the afforested spawning grounds of the Fleet catchment. Dumfries, Forestry Commission (unpublished report).

DRAKEFORD, T. 1982. Management of upland streams (an experimental fisheries management project on the afforested headwaters of the River Fleet, Kirkudbrightshire). Paper presented to Institute of Fisheries Management, 12th Annual Study Course, Durham.

DRURY, W.H., Jr. 1956. Bog flats and physiographic processes in the Upper Kuskokwim River region, Alaska. *Contributions from the Gray Herbarium of Harvard University,* No. 178.

DURIETZ, G.E. 1954. Die Mineralbodenwasser-zeigergrenze als Grundlage einer natürlichen Zweigliederung der nord- und mitteleuropäischen Moore. *Vegetatio, 516,* 571-585.

DURNO, S.E. 1958. Pollen analysis of peat deposits in eastern Sutherland and Caithness. *Scottish Geographical Magazine, 74,* 127-135.

DUXBURY, J.M., & PEVERLY, J.H. 1978. Nitrogen and phosphorus losses from drained *peat Journal of Environmental Quality* 7, 566-580.

EDDY, A, WELCH, D., & RAWES, M. 1969. The vegetation of the Moor House National Nature Reserve in the Northern Pennines, England. *Vegetatio, 16,* 239-284.

EGGELSMANN, R. 1972. Physical effects of drainage in peat soils of the temperate zone and their forecasting. *In: Proceedings of the International Symposium on the Hydrology of Marsh-ridden Areas, Minsk,* 1-11.

EGGLISHAW, H., GARDINER, R., & FOSTER, J. 1986. Salmon catch decline and forestry in Scotland. *Scottish Geographical Magazine, 102,* 57-61.

EIGNER, J,, & SCHMATZLER, E. 1980. *Bedeutung Schutz und Regeneration von Hochmooren.* Greven, Kilda-Verlag (Naturschutz aktuell No. 4).

ELLIS, M.M. 1936. Erosion silt as a factor in aquatic environments. *Ecology, 17,* 29-42.

EUROLA, S. 1962. Über die regionale Einteilung der südfinnischen Moore. [The regional classification of peatlands in south Finland], *Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo, 33,* 163-243.

EUROLA, S., HICKS, S., & KAAKINEN, E. 1984. Key to Finnish mire types. *In: European Mires,* ed. by P.D. Moore, 11-118. London, Academic Press.

EUROLA, S., & HOLAPPA, K. 1985. The Finnish mire type system. *Aquilo, Seria Botanica, 21,* 101-110.

FERGUSON, P., LEE, J.A., & BELL, J.N.B. 1978. Effects of sulphur pollutants on the growth of *Sphagnum* species. *Environmental Pollution, 16,* 151-162.

FITTER, A. 1978. *An Atlas of the Wild Flowers of Britain and Northern Europe.* London, Collins.

FLATBERG, K.I. 1984. A taxonomic revision of the *Sphagnum imbricatum* complex. *KongeligeNorske Videnskabers Selskabs Skrifter, 3,* 1-80.

FOSTER, G.N. 1987. Wetland Coleoptera in the Flow Country. Unpublished report to the Nature Conservancy Council.

FOSTER, G.N, & SPIRIT, M. 1986. *Oreodytes alpinus* new to Britain. *Balfour-Browne Club Newsletter,* No. 36, 1-2.

FOX, AD. 1984. Aspects of the hydrology of Cors Fochno National Nature Reserve. PhD thesis, University College of Wales, Aberystwyth.

FRANCIS, IS. 1987. The rates and processes of blanket peat erosion in Mid-Wales. PhD thesis, University College of Wales, Aberystwyth.

FRASER, GK. 1948. *Peat deposits of Scotland. I. General account.* London, Department of Scientific and Industrial Research (Wartime Pamphlets of the Geological Survey No. 36).

FRY, G.L.A., & COOKE, AS. 1984, *Acid deposition and its implications for nature conservation in Britain.* Peterborough, Nature Conservancy Council (Focus on Nature Conservation No. 7).

FUTTY, D.W., & TOWERS, W. 1982. *Soil Survey of Scotland. 3. Northern Scotland.* Aberdeen, Macaulay Institute for Soil Research.

GALVIN, L.F. 1976. Reclamation and drainage of peatland. *Farm and Food Research, 7,* 58-60.

GEIKIE, J. 1866. On the buried forests and peat mosses of Scotland, and the changes of climate which they indicate. *Royal Society of Edinburgh. Transactions, 24,* 363-384.

GIMINGHAM, C.H, 1984. Some mire systems in Japan. *Botanical Society of Edinburgh. Transactions, 44,* 169-176.

GODLEY, E. 1960. The botany of southern Chile in relation to New Zealand and the sub-Antarctic. *Royal Society. Proceedings, B, 152,* 457-475.

GODWIN, H. 1975. *The History of the British Flora.* 2nd ed. Cambridge, Cambridge University Press.

GODWIN, H. 1978. *Fenland: its ancient past and uncertain future.* Cambridge, Cambridge University Press.

GODWIN, H. 1981. *The Archives of the Peat Bog.* Cambridge, Cambridge University Press.

GODWIN, H., & CONWAY, V.M. 1939. The ecology of a raised bog near Tregaron, Cardiganshire. *Journal of Ecology, 27,* 313-363.

GOODE, D.A. 1970. Ecological studies on the Silver Flowe Nature Reserve. PhD thesis, University of Hull,

GOODE, D.A. 1973. The significance of physical hydrology in the morphological classification of mires. *In: Proceedings of the International Peat Society Symposium, Glasgow, 1973. Classification of Peat and Peatlands,* Paper 3.

GOODE, D.A., & FIELD, E.M. 1978. Notes on the vegetation of Shetland bogs. Nature Conservancy Council (unpublished report).

GOODE, D.A., & LINDSAY, R.A 1979. The peatland vegetation of Lewis. *Royal Society of Edinburgh. Proceedings, 77B,* 279-293.

GOODE, D.A., &RATCLIFFE, D.A. 1977. Peatlands. *In: A Nature Conservation Review,* ed. by D.A. Ratcliffe, Vol. 1, 249-287; Vol. 2, 206-244. Cambridge, Cambridge University Press.

GOODWILLIE, R. 1980. *European Peatlands.* Strasbourg, Council of Europe (Nature and Environment Series, No. 19).

GOODWILLIE, R. 1987. Irish treasure. *Birds, 11,* 32-35.

GORE, A.J. P. 1983a. Introduction. *In: Mires: Swamp, Bog, Fen and Moor. General Studies,* ed. by A.J. P. Gore, 1-34. Amsterdam, Elsevier Scientific (Ecosystems of the World 4A).

GORE, A.J.P., ed. 1983b. *Mires: Swamp, Bog, Fen and Moor. Regional Studies.* Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

GORHAM, E. 1953a. A note on the acidity and base status of raised and blanket bogs. *Journal of Ecology, 41,* 153-156.

GORHAM, E. 1953b. Some early ideas concerning the nature, origin and development of peat lands. *Journal of Ecology, 41,* 257-274.

GORHAM, E. 1966. Some chemical aspects of wetland ecology. *In: Proceedings of the Twelfth Muskeg Research Conference, Ottawa.*

GORHAM, E., BAYLEY, S.E., & SCHINDLER, D.W. 1984. Ecological effects of acid deposition upon peatlands: a neglected field in 'acid-ram' research. *Canadian Journal of Fisheries and Aquatic Science, 41,* 1256-1268.

GRANLUND, E. 1932. De svenska högmossarnas geologie [The geology of the Swedish *Hochmoore].* *Sveriges Geologiska Undersökning. Afhandlingar och Uppsatser, 373,* 1-193.

GRANT, M.C., & LEWIS, W.M. 1982. Chemical loading rates from precipitation in the Colorado Rockies. *Tellus, 34,* 74-88.

GREEN, F.H.W. 1964. A map of annual average potential water deficit in the British *Isles. Journal of Applied Ecology, 1,* 151-158.

GREIG, D.A. 1975. Raised bogs in North-west Cumbria. Report on a vegetation survey of Glasson Moss, Bowness Common and Wedholme Flow, with notes on Drumburgh Moss. Nature Conservancy Council (unpublished report).

GROENENDAEL, J.M. van, HOCHSTENBACH, S.M.H., MANSFELD, M.J.M. van, & ROOZEN, A.J.M. 1975. *The Influence of the Sea and of Parent Material on Wetlands and Blanket Bog in West Connemara, Ireland.* Nijmegen, Catholic University.

GROSSE-BRAUCKMANN, G. 1962. Zur Moorgliederung und -ansprache. *Zeitschrift für Kulturtechnik, 3,* 6-29.

HARRIMAN, R. 1978. Nutrient leaching from fertilized forest watersheds in Scotland. *Journal of Applied Ecology, 15,* 933-942.

HARRIMAN, R., & MORRISON, B.R.S. 1982. Ecology of streams draining forested and non-forested catchments in an area of central Scotland subject to acid precipitation. *Hydrobiologia, 88,* 251-263.

HEAL, O.W., & SMITH, R.A.H. 1978. The Moor House programme. Introduction and site description. *In: Production Ecology of British Moors and Montane Grasslands,* ed. by O. W. Heal and D.F. Perkins, 3-16. Berlin, Springer-Verlag.

HILDREW, A.G, TOWNSEND, OR., FRANCIS, J., & FINCH, K. 1984. Cellulitic decomposition in streams of contrasting pH and its relationship with invertebrate community structure. *Freshwater Biology, 14,* 323-328.

HILL, M.O. 1979. *TWINSPAN - a FORT AN Program for Arranging Multivariate Data in an Ordered Two-way Table by Classification of the Individuals and Attributes.* Cornell University, Ecology and Systematics.

HOBBS, N.B. 1986. Mire morphology and the properties and behaviour of some British and foreign peats. *Quarterly Journal of Engineering Geology, 19,* 7-80.

HOBBS, R.J., &GIMINGHAM, C.H. 1987. Vegetation, fire and herbivore interactions in heathland. *Advances in Ecological Research, 16,* 87-173.

HOLMES, N. 1983. *Typing British rivers according to their flora.* Peterborough, Nature Conservancy Council (Focus on Nature Conservation No. 4).

HORNUNG, M,, & NEWSON, M.D. 1986. Upland afforestation influences on stream hydrology and chemistry. *Soil Use Management, 2,* 61-65.

HULME, P.D. 1980. The classification of Scottish peatlands. *Scottish Geographical Magazine, 96,* 46-50.

HULME, P.D. 1985. The peatland vegetation of the Isle of Lewis and Harris and the Shetland Islands, Scotland. *Aquilo, Seria Botanica, 21,* 81-88.

HULME, P.D. 1986. The origin and development of wet hollows and pools on Craigeazle mire, southwest Scotland. *International Peat Journal, 1,* 15-28.

HULME, P.D., &BLYTH, A.W. 1984. A classification of the peatland vegetation of the Isles of Lewis and Harris, Scotland. *In: Proceedings of the Seventh International Peat Congress, Dublin, 1984, 1,* 188-204.

HULME, P.D., &BLYTH, A.W. 1985. Observations on the erosion of blanket peat in Yell, Shetland. *Geografiska Annaler, 67A,* 119-122.

IGARASHI, Y, AKAZAWA, T,, MATSUSHITA, K., & UMEDA, Y. 1984. Soil characteristics and geohistory on the Ishikari peat land, northern Japan. *In: Proceedings of the Seventh International Peat Congress, Dublin, 1984,* 7, 205-219.

INGRAM, H.A.P. 1967. Problems of hydrology and plant distribution in mires. *Journal of Ecology, 55,* 711-724.

INGRAM, H.AP. 1982. Size and shape in raised mire ecosystems: a geophysical model. *Nature, 297,* 300-303.

INGRAM, H.A.P. 1983. Hydrology. *In: Mires: Swamp, Bog, Fen and Moor General Studies,* ed. by AJ.P. Gore, 67-158. Amsterdam, Elsevier Scientific (Ecosystems of the World 4A).

INGRAM, H.A.P., & BRAGG, O.M. 1984. The diplotelmic mire: some hydrological consequences reviewed. *In: Proceedings of the Seventh International Peat Congress, Dublin, 1984, 1,* 220-234.

IVANOV, K.E. 1981. *Water Movement in Mirelands.* London, Academic Press.

JEFFERIES, T.A 1915. Ecology of the purple heath grass *(Molinia caerulea). Journal of Ecology, 3,* 93-109.

JOHANSEN, J. 1975. Pollen diagrams from the Shetland and Faroe Islands. *New Phytologist, 75,* 369-387.

KATZ, N.Y 1971. *Swamps of the Earth.* Moscow, Nauka.

KEATINGE, T.H., & DICKSON, J.H. 1979. Mid-Flandrian changes in the vegetation of mainland Orkney. *New Phytologist, 82,* 585-612.

KERSHAW, K.A. 1973. *Quantitative and Dynamic Plant Ecology.* London, Arnold.

KLING, G.W., & GRANT, M.C. 1984. Acid precipitation in the Colorado Front Range: an overview with time predictions for significant effects, *Arctic and Alpine Research, 16,* 321-329.

KOMAREK, E.V. 1971. Principles of fire ecology and fire management in relation to the Alaskan environment. *In: Fire in the Northern Environment,* ed. by C. W. Slaughter, R.J. Barney and G.M. Hansen, 3-22. Portland, Oregon, Pacific North West Forest and Range Experiment Station.

KORCHUNOV, S.S., KUSMIN, G.F., & IVANOV, K.E. 1980. Raised bog systems, their structure and influence on the environment. Bog protection. *In: Proceedings of the Sixth International Peat Congress, Duluth, Minnesota, 1980,* 55-58.

LEACH, S.J., & CORBETT, P. McM. 1987. A preliminary survey of raised bogs in Northern Ireland. *Glasra, 10,* 57-73.

LEE, J. A. 1981. Atmospheric pollution and the Peak District blanket bogs. *In: Peak District Moorland Erosion Study. Phase 1 Report,* ed. by J. Phillips, D. Yalden and J. Tallis, 104-109. Bakewell, Peak Park Joint Planning Board.

LEE, J.A, PRESS, M.C., WOODIN, S,, & FERGUSON, P. 1986. Responses to acidic deposition in ombrotrophic mires. *In: Effects of Acidic Deposition on Forests, Wetlands and Agricultural Ecosystems,* ed. by T.C. Hutchinson and K. Meema, 549-560. Berlin, Springer-Verlag.

LEEKS, G.F.L., & ROBERTS, G. 1986. The effects of forestry on upland streams - with special reference to water quality and sediment transport. *In: Environmental Aspects of Plantation Forestry in Wales,* ed. by J.E.G. Good, 9-24. Cambridge, Institute of Terrestrial Ecology (ITE Symposium No. 22).

LEFEBVRE, G., LANGLOIS, P., LUPIEN, C, & LAVALLEE, J. 1984. Laboratory testing on *in situ* behaviour of peat as embankment foundation. *Canadian Geotechnical Journal, 21,* 322-337.

LEWIS, F.J. 1905. The plant remains in the Scottish peat mosses. I. The Scottish Southern Uplands. *Royal Society of Edinburgh. Transactions, 41,* 699-723.

LEWIS, F.J. 1906. The plant remains in the Scottish peat mosses. II. The Scottish Highlands. *Royal Society of Edinburgh. Transactions, 45,* 335-360.

LEWIS, F.J. 1907. The plant remains in the Scottish peat mosses. III. The Scottish Highlands and the Shetland Islands. *Royal Society of Edinburgh. Transactions, 46,* 33-70.

LIKENS, G.E., BORMANN, F.H., JOHNSON, N.M., FISHER, D.W., & PIERCE, R.S. 1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbard Brook watershed ecosystem. *Ecological Monographs, 40,* 23-47.

LINDSAY, R.A. 1977. Glasson Moss and the 1976 fire. Nature Conservancy Council (unpublished report).

LINDSAY, R.A., RIGGALL, J., & BIGNAL, E.M. 1983.

Ombrogenous mires in Islay and Mull. *Royal Society of Edinburgh. Proceedings, 83B,* 341-371.

LINDSAY, R.A., RIGGALL, J., & BURD, F. 1985. The use of small-scale surface patterns in the classification of British peatlands. *Aquilo, Seria Botanica„21,* 69-79.

LYUBIMOVA, E.L. 1940. Nekotorye dannye o bolotakh zapadnago poberezh'ya Kamchatki. *In: Kamchatskii Sbornikl,* 157-225. Moscow, Nauka.

MACDONALD, J., WOOD, R.F., EDWARDS, M.V., & ALDHOUS, J.R., eds. 1957. *Exotic Forest Trees in Great Britain.* London, H.M.S.O. (Forestry Commission Bulletin No. 30).

MacLEAN, D.A., WOODLEY, S.J., WEBER, M.G., & WEIN, R. W. 1983. Fire and nutrient cycling. *In: The Role of Fire in Northern Circumpolar Ecosystems,* ed. by R. W. Wein and D. A. MacLean, 111-132. Chichester, Wiley.

McVEAN, D.N., & LOCKIE, J.D. 1969. *Ecology and Land Use in Upland Scotland.* Edinburgh, Edinburgh University Press.

McVEAN, D.N., & RATCLIFFE, D.A 1962. *Plant Communities of the Scottish Highlands.* London, H.M.S.O. (Monographs of the Nature Conservancy No. 1).

MALCOLM, D.C., & CUTTLE, S.P. 1983. The application of fertilisers to drained peat. 1. Nutrient losses in drainage. *Forestry, 56,* 155-174.

MALMER, N. 1985. Remarks to the classification of mires and mire vegetation. Scandinavian arguments. *Aquilo, Seria Botanica, 21,* 9-17.

MALMER, N., & SJORS, H. 1955. Some determinations of elementary constituents in mire plants and peat. *Botaniska Notiser, 108,* 46-80.

MALTBY, E. 1980. The impact of severe fire on *Calluna* moorland in the North York Moors. *Bulletin d'Ecologie, 11,* 683-708.

MARREN, P. 1986. The lethal harvest of crayfish plague. *New Scientist, 109,* 46-50.

MASING, V. 1984. New bog reserves in the Estonian S.S.R.: their scientific and economic significance. *In: Proceedings of the Seventh International Peat Congress, Dublin, 1984, 1,* 306-313.

MATTHEWS, J.R. 1937. Geographical relationships of the British flora. *Journal of Ecology 25,* 1-90.

MATTHEWS, J.R. 1955. *Origin and Distribution of the British Flora.* London, Hutchinson.

MEADE, R. 1984. Ammonia-assimilating enzymes in bryophytes. *Physiologia Plantarum, 60,* 305-308.

METEOROLOGICAL OFFICE. 1952. *Climatological Atlas of the British Isles.* London, H.M.S.O.

MILLS, D.H. 1980. *The Management of Forest Streams.* London, H.M.S.O. (Forestry Commission Leaflet No. 78).

MOAR, NT. 1969a. Two pollen diagrams from the Mainland, Orkney Islands. *New Phytologist, 68,* 201-208.

MOAR, NT. 1969b. A radiocarbon-dated pollen diagram from north-west Scotland. *New Phytologist, 68,* 209-214.

MOEN, A. 1985. Classification of mires for conservation purposes in Norway. *Aquilo, Seria Botanica, 21,* 95-100.

MOORE, J.J. 1968. A classification of the bogs and wet heaths of Northern Europe. *In: Pflanzen-soziologische Systematik,* ed. by R. Tüxen, 306-320. The Hague, Junk.

MOORE, P.D. 1968. Human influence upon vegetational history in north Cardiganshire. *Nature, 217,* 1006-1009.

MOORE, P.D. 1973a. The influence of prehistoric cultures upon the initiation and spread of blanket bog in upland Wales. *Nature, 241,* 350-353.

MOORE, P.D. 1973b. Objective classification of peats on the basis of their macrofossil content. *In: Proceedings of the International Peat Society Symposium, Glasgow, 1973. Classification of Peat and Peatlands,* Paper 15.

MOORE, P.D. 1977. Stratigraphy and pollen analysis of Claish Moss, north-west Scotland; significance for the origin of surface pools and forest history. *Journal of Ecology, 65,* 375-397.

MOORE, P.D. 1984. The classification of mires: an introduction. *In: European Mires,* ed. by P.D. Moore, 1-10. London, Academic Press.

MOORE, P.D., & BELLAMY, DJ. 1974. *Peatlands.* London, Elek Science.

MOORE, P.D., MERRYFIELD, D.L., & PRICE, M.D.R. 1984. The vegetation and development of blanket mires. *In: European Mires,* ed. by P.D. Moore, 203-232. London, Academic Press.

MOORE, P.D., & WILMOTT, A. [1979], Prehistoric forest clearance and the development of peatlands in the uplands and lowlands of Britain. *In: Proceedings of the Fifth International Peat Congress, Poznán, Poland, 1976, 2,* 7-21.

MORRISON, B.R.S., & WELLS, D.E. 1981. The fate of Fenitrothion in a stream environment and its effect on the fauna following aerial spraying of a Scottish forest. *Science of the Total Environment, 19,* 223-252.

MOSS, C.E. 1913. *The Vegetation of the Peak District.*

Cambridge, Cambridge University Press.

MROSE, H. 1966. Measurements of pH and chemical analyses of rain-, snow- and fog-water. *Tellus, 18,* 266-270.

NATIONAL WATER COUNCIL. 1981. *River Quality: the 1980 survey and future outlook.* London, National Water Council.

NATURE CONSERVANCY COUNCIL. 1982. *Seventh report covering the period 1 April 1980^31 March 1981*. London.

NATURE CONSERVANCY COUNCIL. 1986. *Nature Conservation and Afforestation in Britain.* Peterborough.

NEILAND, B.J. 1971. The forest bog complex of south east Alaska. *Vegetatio, 22,* 1-64.

NEISHTADT, M.I. 1935. Yestestvennye obnazheniya torfa po zapnomy poberezhyu Kamchatki. *Izvestiia Gosudarstvennoe. Geograficheskoe Obshchestvo, 67,* 579-587.

NEISHTADT, M.I. 1936. Torfyanye bolota barbinskoi lesostepi. *Trudy Tsentral. Torf Opytn Stants, 1,* 73-85.

NETHERSOLE-THOMPSON, D. & M. 1979. *Greenshanks.* Berkhamsted, T. and AD. Poyser.

NEWBOLD, C, & PALMER, M.A 1979. *Trophic adaptations of aquatic plants.* London, Nature Conservancy Council (CST Notes No. 18).

NEWSON, M.D. 1980. The erosion of drainage ditches and its effects on bed-load yields in mid-Wales. *Earth Surface Processes and Landforms, 5,* 275-290.

NEWSON, M.D. 1985. Forestry and water in the uplands of Britain: the background of hydrological research and options for harmonious land-use. *Quarterly Journal of Forestry, 79,* 113-120.

NIKONOV, M.N. 1955. Raionirovanie torfyanykh bolot v svyazi s ispol' zovoniem ikh v sel'skom khozyaistve. *Trudy Instituta Lesa, 31,* 49-63.

O'CONNELL, M., RYAN, J.B., & MacGOWRAN, B.A. 1984. Wetland communities in Ireland: a phytosociological review. *In: European Mires,* ed. by P.D. Moore, 303-358. London, Academic Press.

OGILVY, R.S.D. 1986. Whither forestry? The scene in AD 2025. *In: Trees and Wildlife in the Scottish Uplands,* ed. by D. Jenkins, 33-39. Abbots Ripton, Institute of Terrestrial Ecology (ITE Symposium No. 17).

ORMEROD, S.J., MAWLE, G.W., & EDWARDS, R.W. 1986. The influence of forest on aquatic fauna. *In: Environmental Aspects of Plantation Forestry in Wales,* ed. by J.E.G. Good, 37-49. Cambridge, Institute of Terrestrial Ecology (ITE Symposium No. 22).

OSVALD, H. 1923. Die Vegetation des Hochmoores Komosse, Kap. 5. [The vegetation of the raised bogs of Komosse, Chapter 5], *Svenska Växtsociologiska Sällskapets Handlingar, 1,* 265-310.

OSVALD, H. 1949. Notes on the vegetation of British and Irish mosses. *Acta Phytogeographica Suecica, 26,* 1-62.

PALMER, M. A, & NEWBOLD, C. 1983. *Wetland and riparian plants in Britain.* Peterborough, Nature Conservancy Council (Focus on Nature Conservation No. 1).

PARR, W. 1984. Consultation or confrontation? A review of forestry activities and developments on water catchment areas in south-west Scotland. Dumfries and Galloway Regional Council, Water and Sewage Department (unpublished paper presented to the Scientific Section of the Institution of Water Engineers and Scientists, 24 October 1984).

PEARS, N. V. 1975. Tree stumps in the Scottish hill peats. *Scottish Forestry, 29,* 255-259.

PEARSALL, W.H. 1950. *Mountains and Moorlands.* London, Collins (New Naturalist No. 11).

PEARSALL, W.H. 1956. Two blanket-bogs in Sutherland. *Journal of Ecology, 44,* 493-516.

PEARSON, M.C. 1954. The ecology and history of some peat bogs in west Northumberland with special reference to Muckle Moss. PhD thesis, University of Durham.

PEGLAR, S. 1979. A radiocarbon-dated pollen diagram from Loch of Winless, Caithness, north-east Scotland. *New Phytologist, 82,* 245-263.

PEIRSON, D.H., CAWSE, P.A, SALMON, L., & CAMBRAY, R.S. 1973. Trace elements in the atmospheric environment. *Nature, 241,* 252-256.

PENFORD, N. 1985. Islay peatlands: a survey and evaluation of selected sites. MSc thesis, University College London.

PENNINGTON, W. 1974. *The History of British Vegetation.* 2nd ed. London, English University Press.

PERRING, F.H., & WALTERS, S.M., eds. 1976. *Atlas of the British Flora.* 2nded. East Ardsley, Wakefield, EP Publishing, for Botanical Society of the British Isles.

PERRY, A.R. 1965. Distribution maps of bryophytes in Britain: *Sphagnum pulchrum* (Lindb. ex Braithw.) Warnst. *British Bryological Society. Transactions, 4,* 883.

PHILLIPS, J. 1981. Moor burning. *In: Peak District*

Moorland Erosion Study, Phase I Report, ed. by J. Phillips, D. Yalden and J. Tallis, 171-175. Bakewell, Peak Park Joint Planning Board.

PIERSMA, T., ed. 1986. Breeding waders in Europe: a review of population size estimates and a bibliography of information sources. *Wader Study Group Bulletin,* No. 48 (Supplement).

PISANO, E. 1983. The Magellanic Tundra Complex. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A. J. P. Gore, 295-329. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

PRESS, M.C, &LEE, J.A. 1982. Nitrate reductase activity of *Sphagnum* species in the south Pennines. *New Phytologist, 92,* 487-494.

PRESS, M., FERGUSON, P., & LEE, L. 1983. 200 years of acid rain. *Naturalist, 108,* 125-129.

PROCTOR, M.C.F., & ROD WELL, J. 1986. National Vegetation Classification: Mires. 3 vols. University of Lancaster (unpublished draft).

PRUITT, W.O. 1978. *Boreal Ecology* London, Edward Arnold.

PRUS-CHAKINISKI, T.M. 1962. Shrinkage of peat-lands due to drainage operations. *Institution of Water Engineers. Journal, 16,* 436-448.

PRYTZ, K. 1932. *Der Kreislauf des Wassers.* Samfund, Copenhagen, Danmark Naturvidenskabelige.

PYATT, D.G 1987. Afforestation of blanket peatland - soil effects. *Forestry and British Timber, 16(3),* 15, 17.

RATCLIFFE, D. A. 1964. Mires and bogs. *In: The Vegetation of Scotland,* ed. by J.H. Burnett, 426-478. Edinburgh, Oliver and Boyd.

RATCLIFFE, D. A. 1968. An ecological account of Atlantic bryophytes in the British Isles. *New Phytologist, 67,* 365-439.

RATCLIFFE, D.A. 1969. Distribution maps of bryophytes in Britain: *Pleurozia purpurea* Lindb. *British Bryological Society. Transactions, 5,* 833.

RATCLIFFE, D.A, ed. 1977. *A Nature Conservation Review.* 2 vols. Cambridge, Cambridge University Press.

RATCLIFFE, D.A. 1986a. Selection of important areas for wildlife conservation in Great Britain: the Nature Conservancy Councils approach. *In: Wildlife Conservation Evaluation,* ed. By M.B. Usher, 135-159. London, Chapman and Hall.

RATCLIFFE, D.A. 1986b. The effects of afforestation on the wildlife of open habitats. *In: Trees and Wildlife in the Scottish Uplands,* ed. by D. Jenkins, 46-54, Abbots Ripton, Institute of Terrestrial Ecology (ITE Symposium No. 17).

RATCLIFFE, D.A, & WALKER, D. 1958. The Silver Flowe, Galloway, Scotland. *Journal of Ecology, 46,* 407-445.

RATCLIFFE, J.B., & HATTEY, R.P. 1982. Welsh Lowland Peatland Survey (Final report of the Welsh Wetland Survey). London, Nature Conservancy Council, Chief Scientist Team (unpublished report).

RAWES, M., &HOBBS, R 1979. Management of semi-natural blanket bog in the northern Pennines. *Journal of Ecology, 67,* 789-807.

REED, T.M., &LANGSLOW, D.R 1987. Habitat associations of breeding wading birds. *Acta Oecologica/Oecologia Generalis, 8,* 309-311.

REUSS, J.O., & JOHNSON, D.W. 1986. *Acid Deposition and the Acidification of Soils and Waters.* New York, Springer-Verlag (Ecological Studies, Vol. 59).

RICHARDS, W.N. 1984. Problems of water management and water quality arising from forestry activities. *In: Woodlands, Weather and Water,* ed. by D.L. Harding and J.F. Fawell, 67-85. London, Institute of Biology.

ROBERTS, M.E., & JAMES, D.B. 1972. Some effects of forest cover on nutrient cycling and river temperature. *In: Research Papers in Forest Meteorology,* ed. by J.A. Taylor, 100-108. Aberystwyth, Cambrian News.

ROBERTSON, R.A., &JOWSEY, P.C. 1968. Peat resources and development in the United Kingdom. *In: Proceedings of the Third International Peat Congress, Quebec, 1968,* ed. by C. Lafleur and J. Butler, 13-14.

ROBINSON, D. 1987. Investigations into the Aukhorn peat mounds, Keiss, Caithness: pollen, plant macrofossil and charcoal analysis. *New Phytologist, 106,* 185-200.

ROBINSON, M. 1980. *The effect of pre-afforestation drainage on the streamflow and water quality of a small upland catchment.* Wallingford, Institute of Hydrology (Report No. 73).

ROBINSON, M., & BLYTH, K. 1982. The effect of forestry drainage operations on upland sediment yields: a case study. *Earth Surface Processes and Landforms, 7,* 85-90.

ROIVAINEN, H. 1954. Studien über die Moore Feuerlands. [Studies on the bogs of Tierra del Fuego]. *Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo, 28,* 1-205.

ROPER, P. undated. *Holidays in the Falkland Islands.* Stanley, Falkland Islands, Falkland Islands Tourism.

ROWE, J.S. 1983. Concepts of fire effects on plant individuals and species. *In: The Role of Fire in Northern Circumpolar Ecosystems,* ed. by

R.W. Wein and D.A. MacLean, 135-154. Chichester, Wiley.

ROYAL SOCIETY FOR THE PROTECTION OF BIRDS. 1985. *Forestry in the Flow Country-the Threat to Birds.* Sandy.

RUUHIJARVI, R. 1960. Über die regionale Einteilung der nordfinnischen Moore. *Annales Botanici Societatis Zoologicae Botanicae Fennicae Vanamo, 31,* 1-360.

RUUHIJARVI, R.E. 1983. The Finnish mire types and their regional distribution. *In: Mires: Swamps, Bog, Fen and Moor. Regional Studies,* ed. by A.J. P. Gore, 47-67. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

RYAN, J.B., & CROSS, J.R. 1984. The conservation of peatlands in Ireland. *In: Proceedings of the Seventh International Peat Congress, Dublin, 1984, 1,* 388-406.

RYBNICEK, K. 1985. A central European approach to the classification of mire vegetation. *Aquilo, Seria Botanica, 21,19-31.*

RYDIN, H, & McDONALD, AJ.S. 1985. Tolerance of *Sphagnum* to water level. *Journal of Bryology, 13,* 571-578.

SAGE, B. 1986. *The Arctic and its Wildlife.* Beckenham, Croom Helm.

SCHUNKE, E. 1977. Zür Ökologie der Thufur Islands. *Berichte aus der Forschungsstelle Nedri As, Hveragerdi, 26.*

SCHWAAR, J. 1977. Humifizierungswechsel in terrainbedeckende Mooren von Gough Island, Südatlantik. *Telma, 7,* 77-90.

SCOTTISH WILDLIFE TRUST. 1987. *The Future of the Flows.* Edinburgh.

SERNANDER, R. 1908. On the evidence of Postglacial changes of climate furnished by the peat-mosses of northern Europe. *Geologiska Föreningens i Stockholm Förhandlingar, 30,* 467-478.

SERNANDER, R. 1910. Ausstellung zur Beleuchtung der Entwicklungsgeschichte der swedischen Torfmoore. *Congrès géologique international. Compte rendu de la XI session,* 203-211.

SHARROCK, J.T.R., ed. 1976. *The Atlas of Breeding Birds in Britain and Ireland.* Tring, British Trust for Ornithology/Irish Wildbird Conservancy.

SHIRT, D.B., ed. 1987. *British Red Data Books: 2. Insects.* Peterborough, Nature Conservancy Council.

SIMMONS, I.G. 1963. The blanket bog of Dartmoor. *Devonshire Association for the Advancement of Science, Literature and Art. Report and Transactions, 95,* 180-196.

SIMMONS, I.G., &CUNDILL, P.R. 1974. Late quaternary vegetational history of the North York Moors. I. Pollen analyses of blanket peats. *Journal of Biogeography 1,* 159-169.

SJORS, H. 1948. Myrvegetation l Bergslagen. [Mire vegetation in Bergslagen, Sweden]. *Acta Phytogeographica Suecica, 21,* 1-299. [English summary: 277-299].

SJORS, H. 1950a. On the relation between vegetation and electrolytes in north Swedish mire waters. *Oikos, 2,* 241-258.

SJORS, H. 1950b. Regional studies in north Swedish mire vegetation. *Botaniska Notiser, 103,* 173-222.

SJORS, H. 1961. Surface patterns in boreal peatland. *Endeavour, 20,* 217-224.

SJORS, H. 1983. Mires of Sweden. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A.J. P. Gore, 69-94. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

SJORS, H. 1984. Peatlands and their development in southern Alaska. *In: Proceedings of the Seventh International Peat Congress, Dublin, 1984, 1,* 443-449.

SJORS, H. 1985a. A comparison between mires of southern Alaska and Fennoscandia. *Aquilo, Seria Botanica, 21,* 89-94.

SJORS, H. 1985b. On classification with respect to mires. *Aquilo, Seria Botanica, 21,* 117-119.

SKEFFINGTON, R. A, & ROBERTS, T.M. 1985. The effects of ozone and acid mist on Scots pine saplings. *Oecologia, 65,* 201-206.

SLATER, F.M., & AGNEW, A.D.Q. 1977. Observations on a peat bog's ability to withstand increasing public pressure. *Biological Conservation, 11,* 21-27.

SLATER, F.M., & SLATER, E.J. 1978. The changing status of *Sphagnum imbricatum* Hornsch. ex Russ. on Borth Bog, *Wales. Journal of Bryology, 10,* 155-161.

SMART, P.J. 1982. Stratigraphy of a site in the Munsary Dubh Lochs, Caithness, northern Scotland: development of the present pattern. *Journal of Ecology 70,* 549-558.

SMART, P.J. 1983. The plant ecology of re-vegetated peat cuttings in ombrotrophic mires, with special reference to Thorne Moors, South Yorkshire. PhD thesis, University of Sheffield.

SMITH, A.G. 1970. The influence of mesolithic and neolithic man on British vegetation. *In: Studies in the Vegetational History of the British Isles,* ed. by D. Walker and R.G. West, 81-96. London, Cambridge University Press.

SMITH, A.J.E. 1978. *The Moss Flora of Britain and*

Ireland Cambridge, Cambridge University Press.

SMITH, B.D. 1980, The effects of afforestation on the trout of a small stream in southern Scotland, *Fisheries Management, 11,* 39-58.

SMITH LT ed. 1910. *The Itinerary of John Leland in or about the Years 1535-1543.* Vol. 5 (Part IX). London, G. Bell and Sons.

SPARLING, J.H. 1962. Occurrence of *Schoenus nigricans* L. in the blanket bogs of western Ireland and northwest Scotland. *Nature, 195,* 723-724.

SPARLING, J.H. 1967a. The occurrence of *Schoenus nigricans* L. in blanket bogs. I. Environmental conditions affecting the growth of *S nigricans* in blanket bog. *Journal of Ecology, 55,* 1-13.

SPARLING, J.H. 1967b. The occurrence of *Schoen us nigricans* L. in blanket bogs. II. Experiments on the growth of *S. nigricans* under controlled conditions. *Journal of Ecology, 55,* 15-31.

SPARLING, J.H. 1968. Biological flora of the British Isles. *Schoenus nigricans* L. *Journal of Ecology, 56,* 883-899.

SPENCE D.H.N. 1974. Subarctic debris and scrub vegetation of Shetland. *In: The Natural Environment of Shetland,* ed. by R. Goodier, 73-88. Edinburgh, Nature Conservancy Council.

SPIRIT, M.G., comp. [1987], *Freshwater Invertebrates of Caithness.* Wick, Caithness and Sutherland District Councils Community Programmes Agency.

STACH *et al.* 1975. *Coal Petrology.* Berlin, Gebruder Borntraeger.

STEINER, G.M. 1984. Ö*sterreichischer Moorschutzkatalog [Austrian Mire Conservation Catalogue].* Vienna, Verlag BMGU.

STEWART, A.J. A. 1980. *The environmental impacts of moor gripping.* London, Nature Conservancy Council (CST Report No. 296).

STEWART, A.J.A., & LANCE, AN. 1983. Moor-draining: a review of impacts on land use. *Journal of Environmental Management, 17,* 81-99.

STONER, J.H, GEE, A.S., & WADE, K.R 1984. The effects of acidification on the ecology of streams in the upper Tywi catchment in west Wales. *Environmental Pollution (Series A), 35,* 125-157.

STONER, J.H., &GEE, A.S. 1985. Effects of forestry on water quality and fish in Welsh rivers and lakes. *Institution of Water Engineers. Journal, 39,* 27-45.

STROUD, A.D., REED, T.M., PIENKOWSKI, M.W., & LINDSAY, R.A. 1987. *Birds, Bogs and Forestry.* Peterborough, Nature Conservancy Council.

SUCCOW, M. 1974. Vorschlag einer systematischen Neugliederung der mineralbodenwasser-beeinflussten wachsenden Moorvegetation Mitteleuropas unter Ausklammerung des Gebirgsraumes. *Feddes Repertorium, 85,* 57-113.

SUCCOW, M. 1980. Die Moortypen der DDR und ihre Bewertung fur die Humuswirtschaft. *Zeitschrift fur Angewandte Geologie, 26,* 193-203.

SUCCOW, M,, & LANGE, E. 1984. The mire types of the German Democratic Republic. *In: European Mires,* ed. by P.D. Moore, 149-176. London, Academic Press.

TALLIS, J.H. 1964a. Studies on southern Pennine peats. I.' The general pollen record. *Journal of Ecology, 52,* 323-331.

TALLIS, J.H. 1964b. Studies on southern Pennine peats. II. The pattern of erosion .*Journal of Ecology,* 52,333-344.

TALLIS, J.H. 1964c. Studies on southern Pennine peats. III. The behaviour of *Sphagnum. Journal of Ecology, 52,* 345-353.

TALLIS, J.H. 1975. Tree remains in southern Pennine peats. *Nature, 256,* 482-484.

TALLIS, J.H. 1981. Causes of erosion, a working hypothesis. *In: Peak District Moorland Erosion Study. Phase 1 Report,* ed. by J. Phillips, D. Yalden and J. Tallis, 224-234. Bakewell, Peak Park Joint Planning Board.

TANSLEY, AG. 1939. *The British Islands and their Vegetation.* London, Cambridge University Press.

TAYLOR, J. A, 1983, The peatlands of Great Britain and Ireland. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A.J.P. Gore, 1-46. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

THOMPSON, K. 1980. Peat and peatlands: structure, functioning and classification. *In: Soil Groups of New Zealand. Part 4. Organic Soils,* ed. by F.C.C.H. van der Elst and D.I. Kinloch, 7-16. New Zealand Society of Soil Science.

THOMPSON, K,, & HAMILTON, A.C. 1983. Peatlands and swamps of the African continent. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A.J. P. Gore, 331-373. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).

TOLONEN, K., PAIRANEN, J., & KURKI, M. 1982. Classification and some physical and chemical characteristics of peat soils. *In: Peatlands and their Utilization in Finland,* ed. by J. Lame, 29-41. Helsinki, Finnish Peatland Society.

TOLPA, S,, JASNOWSKI, M,, & DALCZYNSKI, A. 1967. System der genetischen Klassifizierung des Torfes Mitteleuropas. *Zeszyty Problemowe*

Postepów Nauk Rolniczych, 76, 9-99.

TOMLINSON, G.H., BROUZES, R.J.P., McLEAN, R.A.N., & KADLECEK, J. 1980. The role of clouds in atmospheric transport of mercury and other pollutants. *In: Ecological Impact of Acid Precipitation,* ed. by D. Drablos and A. Tollan, 134-137. Oslo, SNSF.

TROLL, C. 1944. Strukturboden, Solifluktion und Frostklimate der Erde. *Geologische Rundschau, 34,* 617-679.

TUBRIDY, M. 1984. *Creation and Management of a Heritage Zone at Clonmachnoise, Co. Offaly, Ireland.* Final Report (EEC Contract No. 6611/12). Dublin, Trinity College.

TUHKAMEN, S. 1987. The phytogeographical position of the Faeroe Islands and their ecoclimatic correspondences on other continents: problems associated with highly oceanic areas. *Annales Botanici Fennici, 24,* 111-135.

UNITED KINGDOM REVIEW GROUP ON ACID RAIN. 1987. *Acid Deposition in the United Kingdom 1981-1985.* Stevenage, Warren Spring Laboratory.

von POST, L„ & GRANLUND, E. 1926. Södra Sveriges torvtillgångar. I. *Sveriges Geologiska Undersökning, C, 335,* 1-127.

WACE, N. 1960. The botany of the southern oceanic islands. *Royal Society. Proceedings, B, 152,* 475-491.

WACE, N. 1961. The vegetation of Gough Island. *Ecological Monographs, 31,* 337-367.

WALKER, D. 1961. Peat stratigraphy and bog regeneration. *Linnean Society of London. Proceedings, 172,* 29-33.

WALTERS, H, & LEITH, H. 1960. *Klimadiagramm-Weltatlas. [World Atlas of Climate Diagrams].* Jena.

WARREN SPRING LABORATORY. 1987. *United Kingdom Acid Ram Monitoring. Results for 1986.* Stevenage.

WEIN, R.W. 1983. Fire behaviour and ecological effects in organic terrain. *In: The Role of Fire in Northern Circumpolar Ecosystems,* ed. by R. W. Wein and D.A. MacLean, 81-95. Chichester, Wiley.

WEIN, R.W., &MacLEAN, D.A., eds. 1983. *The Role of Fire in Northern Circumpolar Ecosystems.* Chichester, Wiley, on behalf of Scientific Committee on Problems of the Environment (SCOPE) of International Council of Scientific Unions (ICSU).

WELLS, D.E., &ZOLTAI, S. 1985. Canadian system of wetland classification and its application to circumboreal wetlands. *Aquilo, Sena Botanica, 21,* 45-52.

WELLS, S.M., PYLE, R.M., & COLLINS, N.M., eds. 1983. *The IUCN Invertebrate Red Data Book.* Gland, Switzerland, International Union for Conservation of Nature and Natural Resources.

WELSH WATER AUTHORITY. 1987. Afforestation in areas sensitive to acidification. Unpublished interim guidelines.

WHEELER, B.D. 1980a. Plant communities of rich-fen systems in England and Wales. I. Introduction - Tall sedge and reed communities. *Journal of Ecology, 68,* 365-395.

WHEELER, B.D. 1980b. Plant communities of rich-fen systems in England and Wales. II. Communities of calcareous mires. *Journal of Ecology, 68,* 405-420.

WHEELER, B.D. 1980c. Plant communities of rich-fen systems in England and Wales. III. Fen meadow, fen grassland and fen woodland communities, and contact communities, *Journal of Ecology 68,* 761-788.

WHEELER, B.D. 1984. British fens - A review. *In: European Mires,* ed. By P.D. Moore, 237-281. London, Academic Press.

WICKMAN, F.E. 1951. The maximum height of raised bogs and a note on the motion of water in soligenous mires. *Geoligiska Föreningens i Stockholm Förhandlingar, 73,* 413-422.

WILLIAMS, C.T., DAVIS, B.N.K., MARRS, R.H., & OSBORN, D. 1987. *Impact of pesticide drift.* Huntingdon, Institute of Terrestrial Ecology, Monks Wood Experimental Station (contract report to NCC; ITE Project 1078).

WILSON, H., & WOMERSLEY, L. 1975. *Caithness County Structure Plan: Report of Survey.* Thurso, Caithness County Council.

WOIKE, M„ &SCHMATZLER, E. 1980. *Moore. Bedeutung - Schutz - Regeneration.* Bonn, Deutscher Naturschutzring.

WOODIN, SJ. 1986. Ecophysiological effects of atmospheric nitrogen deposition on ombrotrophic *Sphagnum* species. PhD thesis, University of Manchester.

YALDEN, D. 1981. Sheep and moorland vegetation-a literature review. *In: Peak District Moorland Erosion Study. Phase 1 Report,* ed. by J. Phillips, D. Yalden and J. Tallis, 132-141. Bakewell, Peak Park Joint Planning Board.

YOUNG, M„ & WILLIAMS, J. 1983. The status and conservation of the freshwater pearl mussel *Margaritifera margaritifera* (Linn.) in Great Britain. *Biological Conservation, 25,* 35-52.

ZOLTAI, S.C., &POLLETT, F.C. 1983. Wetlands in Canada: their classification, distribution and use. *In: Mires: Swamp, Bog, Fen and Moor. Regional Studies,* ed. by A.J. P. Gore, 245-268. Amsterdam, Elsevier Scientific (Ecosystems of the World 4B).