Upper Teesdale

[NY 819 290]

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Introduction

Red Sike Moss is situated on the Upper Teesdale National Nature Reserve and SSSI on Widdybank Fell, Durham. This fell is a raised limestone plateau at 523 m OD. To the west is the Cow Green reservoir and the Cautley Snout waterfall; the ground to the south and south-east falls to the River Tees at Falcon Clints. The area is underlain by the Melmerby Scar Limestone (Lower Carboniferous Limestone Series) and the quartz-dolerite Whin Sill, which was intruded into the limestone at the end of the Carboniferous Period. This intrusion partially metamorphosed the limestone to form the Sugar Limestone, which is important for the development and preservation of the Teesdale flora. Red Sike Moss is located between Red Sike and Tinkler's Sike and it has an actively growing surface of *Sphagnum* species, including *Calluna vulgaris, Eriophorum vaginatum* and *E. angustifolium, Erica tetralix, Narthecium ossifragum, Drosera rotundifolia* and many *Carex* species. The western end of the moss shows erosion by drainage channels (Figure 8.7) and has a drier surface than the central part. The moss lies just to the south, and at the foot of the slope, where one of the larger outcrops of Sugar Limestone occurs.

The site is important for reconstructing Flandrian vegetation history in Upper Teesdale, which is an area of international botanical importance, containing a number of species such as *Gentiana verna* and *Kobresia simpliciuscula,* which are found in only a few other locations in Britain and *Minuartia stricta,* which is found nowhere else (Turner *et al.,* 1973; Bradshaw and Clark, 1976; Ratcliffe, 1978). These Teesdale rarities represent a wide range of geographical elements in Europe and represent a convergence of phytogeographical elements (Piggott, 1956; Bradshaw and Clark, 1965, Bradshaw, 1970). The rarities occur in communities occupying habitats of diverse character. Many are found in various grassland communities (Shimwell, 1968), existing as windows in the acidophilous moorland cover. Other communities that include rarities have a more limited distribution, and are associated with certain mining spoil heaps with high lead and zinc concentrations, where base-rich drainage water flows over the surface, and those on quartz-dolerite and limestone screes. They have aroused considerable discussion as to their origin and potential survival ever since the early and mid-nineteenth centuries (Backhouse, 1844) and subsequently (Blackburn, 1931; Godwin, 1949; Piggott and Walters, 1954; Piggott, 1956; Hutchinson, 1966; Bellamy *et al.,* 1969a, b; Squires, 1970, 1971; Bradshaw *et al.,* 1976; Clapham, 1978; Turner, 1978). The list in Winch *et al.* (1805) shows that most of the famous Teesdale plants had been found there by 1805. The decision taken by the Tees and Cleveland Water Board in 1966 to build a reservoir and drown the stretch of the Tees above Cauldron Snout emphasized the conservation importance of the area (Turner *et al.,* 1973; Squires, 1978) and it has provided opportunities to study the origin of plant assemblages and the factors that have enabled the rarities to persist in such assemblages (Bellamy *et al.,* 1969a, b; Squires, 1970; Turner *et al.,* 1973).

Description

The stratigraphy can be seen along the edge of Tinkler's Sike and was examined along three transects (Figure 8.7) by Turner *et al.* (1973). The transects are shown in (Figure 8.8), where it can be seen that the peat depth varies from 1 m at the margin to a 4 m maximum in the centre. Samples for pollen analysis were collected from the points marked TSI, RSI and RSII on (Figure 8.7). The detailed stratigraphy at TSI is given in (Table 8.4) and the pollen diagram in (Figure 8.9). This diagram was zoned according to the major assemblages, which are, starting with the youngest:

Zone G a grass–plantain–heather assemblage

Zone A an oak–alder assemblage

Zone 0 an oak–elm–hazel assemblage

Zone H a hazel–pine assemblage

Zone HJ a hazel–juniper–willow assemblage

Zone J a juniper–willow–herb assemblage

The pollen diagram from RSII is given in (Figure 8.10). The results from RSI show only the bottom part of the profile and peat formation did not start until zone H. The bottom of the blanket peat at position BSIII has a zone A pollen assemblage and the upper peat, some 35 cm above in BSIII, has a zone G pollen assemblage. The pollen diagram is shown in (Figure 8.11).

The relationships between these local pollen assemblage zones and those of Godwin (1940) and the chronozones of West (1970) are given in (Table 8.5). The ^{14}C dates for TSI are shown in (Table 8.6). A summary pollen diagram is given in (Figure 8.12).

Interpretation

Late-glacial c. 10 000 years BP

The Late-glacial Zone III deposit indicates a period of herbaceous vegetation with abundant grasses and sedges and a wide variety of other species. These include such common Late-glacial species as *Artemisia, Filipendula, Helianthemum, Rumex* and *Thalictrum. Betula nana,* juniper and willow species pollen occur in sufficient quantity to indicate that locally these shrubs were flourishing (Figure 8.13)a. The area would have provided a wide variety of micro-habitats from wet, peaty areas near the sikes to the well-drained, Sugar Limestone outcrops.

At TSI the basal few centimetres are thought to have formed in the Late-glacial pollen assemblage zone J, corresponding to very late in Godwin's Zone III. The evidence comes from the very low tree pollen percentages and over 20% juniper pollen, together with a ^{14}C date of 9900 years BP for the 135 cm level. The peat above this level has a different pollen assemblage, with a high percentage of hazel and both oak and elm recording up to 10%. This assemblage, together with a date of 8250 years BP for the 120 cm level at the end of pollen assemblage zone H, indicates that it is part of Godwin's Zone VI. This means that there is a depositional break during Zones IV and V.

10 000–8800 years BP

In this period the peat stopped growing, but began forming again in pollen assemblage zone H. By the beginning of this zone the total tree pollen appears only marginally higher than at the end of the Late-glacial. Graminae, Cyperaceae and other herbaceous pollen frequencies have decreased correspondingly, but they are still well represented at the end of the period. There is no question of closed woodlands having formed.

8800–8000 years BP

In this period (pollen assemblage zone H), oak and elm pollen appear and the frequency of hazel is high. There is no juniper but willow and herbaceous pollen types are still abundant. The total tree pollen frequencies rise steadily on the TSI diagram and by 8000 years BP the frequency is between 30 and 40%. Birch and pine are increasing but it is unlikely there would be closed woodland.

8000–5770 years BP

At the beginning of this period the pine frequency is high and alder and oak low, or zero. By the end the latter two species have risen to high values and pine has disappeared. It is clear that pine grows best on the limestone and persisted there for longer than it did elsewhere (Turner *et al.,* 1973). This conclusion is supported by the fact that *Carex ericetorum* (a Teesdale rarity) is now restricted to the Sugar Limestone. Today it grows in the ground flora of pinewoods in European Russia (Keller, 1927), and where it occurs in the grassland of the East Anglian Breckland it is thought by Watt (1971) to indicate the former existence of pinewoods.

5770–5000 years BP

In this period there is evidence for a long break in peat formation from sometime before 5000 years BP until well after 3390 ± 90 years BE At TSI the major oak–elm–hazel pollen assemblage of zone 0 can be subdivided into Oa (no alder), Ob (little alder) and Oc (higher values for oak and alder and lower for pine: see (Table 8.5)). Pollen assemblage zone A from 40 cm upwards, with low elm frequencies, corresponds to part of Godwin's Zone VIIb. There is stratigraphical evidence for a depositional break between pollen assemblage zones Oc and A, and the ^{14}C of 3390 years BP is much too young for the elm decline at the beginning of Zone VIIb. A break in peat growth of at least 1600 years must have occurred. The fresh peat at 3390 years BP is different from that below, being less humified and composed mainly of *Sphagnum* species.

(Table 8.4) Stratigraphy at TSI, Red Sike Moss (after Turner *et al.,* 1973)

Depth (cm)	Description
0–12	Dark brown crumbly *Calluna* peat with some *Eriophorum* remains, *Juncus* seeds, megaspores of *Selaginella selaginoides* with *Carex* seeds
12–25	Light brown, *Calluna–Eriophorum* peat containing remains of sedges and megaspores of *Selaginella*
25–40	Dark brown peat containing burnt *Calluna* stems
40–112	Dry, moderately humified, light brown *Phragmites* peat with burnt *Calluna* stems, seeds of *Carex* sp. and *Menyanthes trifoliata* and megaspores of *Selaginella*
112–135	Light brown *Phragmites* peat containing twigs of *Betula,* leaves and seeds of *B. nana,* seeds of *Menyanthes* and *Carex* sp., a single seed of *Lychnis flos-cuculi,* Chara oospores and megaspores of *Selaginella*
135–143	*Phragmites* peat with a few *Betula* fragments and seeds of *Carex* sp., *Carduus cirsium* sp., *Viola* sp. and *Lychnis flos-cuculi* and megaspores of *Selaginella*

At the time of the forest maximum the tree pollen frequency contributed between 30–50% of the total pollen spectrum on the Teesdale diagrams (Turner *et al.,* 1973), which contrasts, for example, with the Cranberry Bog (County Durham) lowland diagram (Turner, 1970), where the herb frequency averages some 5% as opposed to the 30–40% for Upper Teesdale. Hence the woods were open compared with the lowlands, to allow a varied herbaceous flora to flourish and contribute a large percentage to the total pollen spectrum.

5000 years BP and later

The open woodland covering most of Upper Teesdale by 5000 years BP was replaced where the soil was becoming waterlogged by blanket peat and where it was better drained by grassland. The change from woodland to blanket peat seems to have been an irreversible process. At Tinkler's Sike there are a series of alternating high and low Graminae and *Plantago* frequencies near the top, and as these changes occur in the 15 cm of peat above the level dated at 2570 ± 80 years BP, it seems likely that they represent varying intensities of human occupation from the Late Bronze Age onwards. This is pollen assemblage Zone G and is correlated with Godwin's Zone VIII.

The pollen record of the Teesdale rarities

Of the 75 species of flowering plants described by Piggott (1956), 16 have pollen that is diagnostic at species level and 11 have been recorded in the Upper Teesdale pollen diagrams (Turner *et al.,* 1973). These are indicated in (Table 8.7). The species found at Red Sike Moss are discussed below. *Betula nana* ((Figure 8.13)a) has been present on Widdybank

Fell throughout the Flandrian and has been much more abundant than it is today. It was unknown on the fell until Hutchinson (1966) found a few small plants growing on dry, heather-covered peat and demonstrated its presence in the past by finding subfossil leaves in the peat beneath. *Gentian verna* was recorded from pollen assemblage zone Oa on Red Sike Moss (RSII) and zone H in the blanket peat basal samples II and III (Turner *et al.,* 1973), so confirming its existence in the area during the maximum forest development and later. *Helianthemum* species have been found in pollen assemblage zone H (RSI), zone O (RSII) and zones A and G at many sites in Upper Teesdale. It has been present throughout the Late- and Post-Glacial periods and has expanded with the spread of grassland. *Plantago maritima* has been recorded from pollen assemblage zone G at Tinider's Sike and (Figure 8.9) Red Sike Moss TSI (after Turner *et al.,* 1973) : tree pollen diagram. See (Figure 8.8) for key to the stratigraphical log. (Figure continued on opposite page for herb pollen.)

(Table 8.6) PIC dates from TSI, Red Sike Moss. They were dated at the Gakushuin laboratory (Japan) and the dates were based on the Libby half-life of 5570 ± 30 years (after Turner *et al.,* 1973)

Laboratory code	**Depth (cm)**	**Pollen horizon**	**Age, in radiocarbon years BP (before 1950)**
GaK-2027	14	Rise in Gramineae *Callum* and *Plantago;* beginning of zone G	2570 ± 80
GaK-2028	44	Beginning of zone A	3390 ± 90
GaK-2029	70	Beginning of subzone Oc	6150 ± 160
GaK-2030	120	End of zone H	8250 ± 280
GaK-2031	135	End of zone J	9900 ± 190

Red Sike, which indicates that it has increased with the spread of grassland too. *Polygonum viviparum* is recorded in pollen assemblage zone G at Red Sike Moss and zone J at TSI, and seems to have been most abundant when the limestone grassland spread to its maximum extent. *Saxifraga stellaris* has been recorded from RSII in zones J and G, and from RSII and Tinkler's Sike in zone 0, so demonstrating its presence in the Late-glacial, at the forest maximum and since the expansion of blanket bog and grassland.

The records for *G. verna, Dryas octopetala* (Figure 8.13)b, *B. nana, Saxifraga azoides* and *S. stellaris, H. canum and Thalictrum alpina* from pollen assemblage zone 0, the period of forest maximum, confirm that these rare species have been in Upper Teesdale since the Late-glacial to the present day. 'What is true for them is probably true for the other rare species, even though the diagnostic pollen has not been recorded.

Fossil remains of many of the rarities have been found in many parts of Britain during the Late Devensian and so the Teesdale assemblage is relict. It has been assumed that the present open communities contain those components of the Late Devensian vegetation that persisted in refugia during the Flandrian where positive processes ensured their survival (Piggott and Walker, 1954; Godwin, 1956; Piggott, 1956). However, some of the habitats in which the rarities are found today are the result of ecological change during the Flandrian (Bellamy *et al.,* 1969a, b; Squires, 1970, 1971, 1978; Turner *et al.,* 1973). Minimum competition is a feature of all the communities containing rarities. Their survival during the woodland phase (8000–3000 years BP) depended on the presence of treeless areas, or a low tree density, because many of the rarities are heliophytes and therefore open woodland or woodland with some openings was necessary.

When the blanket peat developed about 5500 years BP there was a critical period for the rarities, all herb values declined because of increasing heather and they were restricted to peat-free areas. After 3000 BP trees were replaced mainly by grassland. At high altitudes in Teesdale, woodland regeneration may have been limited and once trees were eliminated, grassland species were encouraged in the base-rich areas. Tree destruction might have been caused by grazing and browsing of native fauna, such as the aurochs (Johnson and Dunham, 1963), or the red deer (Dimbleby and Simmons, 1974). The grazing intensity may well have increased as the area available decreased with the continued extension of the blanket peat. Increases in the origin and extent of grassland also have been interpreted as a result of prehistoric peoples' activities (Turner *et al.,* 1973). Evidence comes from microliths and the remains of domestic cattle (Johnson and Dunham, 1963; Proctor, 1965, 1976) and implicit evidence is present in the pollen diagrams (Squires, 1970, 1971, 1978;

Turner *et al.,* 1973), particularly the grass pollen and ruderal pollen, especially ribwort plantain.

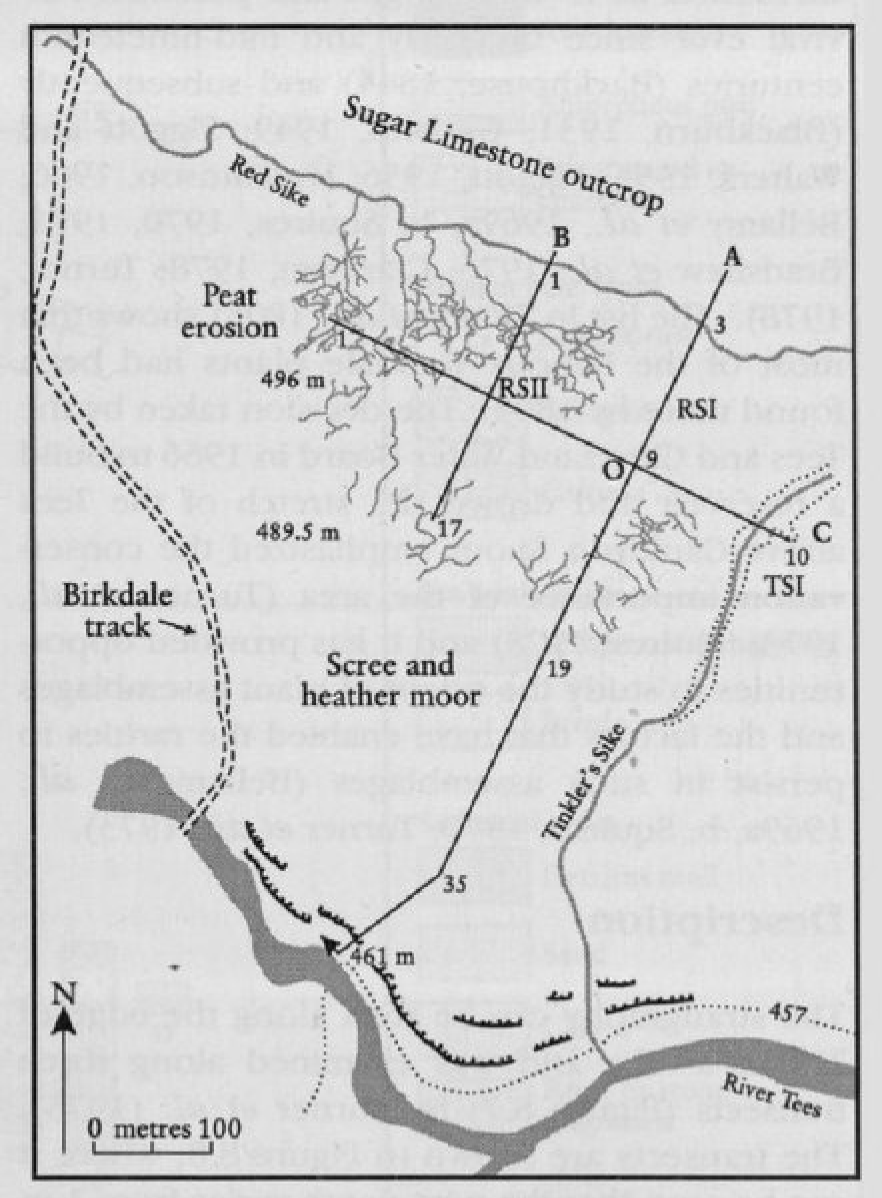
During the blanket peat initiation and extension in the mid-Flandrian many refugia disappeared. By contrast removal of woodland promoted the erosion of substrates and one result was the creation of habitats such as those found on the Sugar Limestone. This allowed the migration of rarities from their diminished refugia and resulted in the creation of new communities. Johnson *et al.* (1971) argued that the Sugar Limestone is a subsurface phenomenon formed beneath a thin drift cover or soil, its presence at the surface being the result of subaerial erosion of the overlying sediment. The present Sugar Limestone outcrops are the product of either the past 5000 years (Turner *et al.,* 1973), or the past 3000 years (Squires, 1978). So most of the rarities in the Teesdale assemblage are relict, that is individually they have a history of 10 000–12 000 years in the area but the palaeoecological evidence suggests that their present-day distribution is not relict. The rarities are more widespread now than at any other time in their Flandrian history because many of the present-day habitats are recent, or at most 5000 years old. Only those areas such as flushes, springs, quartz-dolerite and limestone screes have been long-standing refugia. These areas must have been crucial in the survival of rare species, particularly during the blanket bog extension. However, at least three species that once belonged to the relict flora have become extinct within comparatively recent times: sainfoin and the purple saxifrage since the spread of grassland and blanket bog, and Jacob's ladder within the past 150 years (Turner *et al.,* 1973). Thus the present widespread distribution of the rarities can be looked at as the latest stage in the following sequence (Squires, 1978).

1. *c.* 10000–8000 years BP: widespread distribution with the predominance of positive processes; i.e. local instability from gelifluction and groundwater fluctuations, minimal competition and base-rich soils and surface water.
2. *c.* 8000–3000 years BP: minimal distribution with the preponderance of negative processes; i.e. soil leaching, tree immigration and blanket peat development restricted rarities to refugia.
3. *c.* 3000 years BP: increased distribution because of increasing positive processes that characterize the modern habitats, which allowed the expansion of refugia; i.e. large-scale and local instability (groundwater fluctuations, erosion especially by wind, trampling and burrowing, minimal competition and human interference).

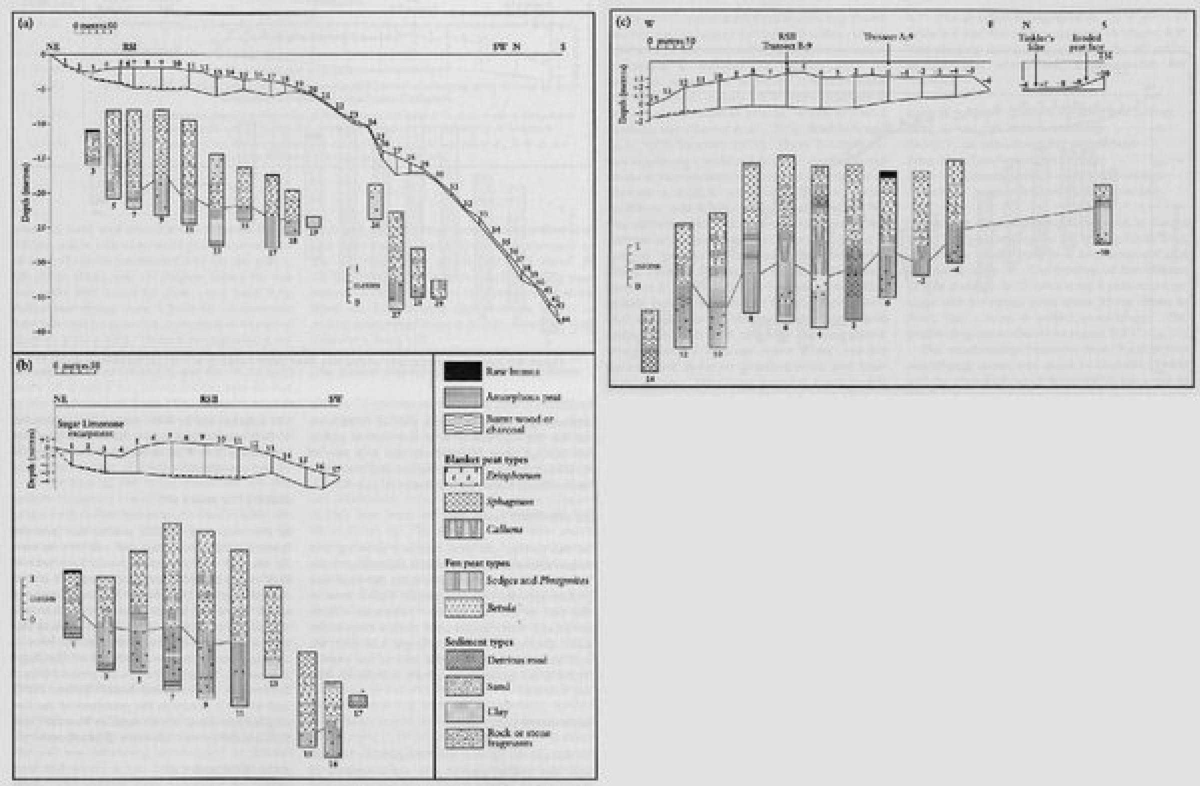
Conclusions

Red Sike Moss and other sites in Upper Teesdale are very important sites where it is possible to see the changes in the Late-glacial and Flandrian flora and where the complex history of the Teesdale rarities can be established. It is one of the most important locations in Britain for conservation: its rare plant assemblages and its palaeoecological development can be compared with both lowland sites in County Durham, such as Neasham Fen (see site report, this chapter), and higher sites on the Moor House National Nature Reserve, such as Valley Bog (see site report, this chapter).

References



(Figure 8.7) Location of Red Sike Moss and the tran-sects along which borings were made and the position of pollen diagrams TSI, RSI and RSII (after Turner



(Figure 8.8) A stratigraphy of Red Sike Moss (after Turner et al., 1973): (a) along transect A; (b) along transect B; see overleaf for (c) along transect C.

Depth (cm)	Description
0–12	Dark brown crumbly *Calluna* peat with some *Eriophorum* remains, *Juncus* seeds, megaspores of *Selaginella selaginoides* with *Carex* seeds
12–25	Light brown, *Calluna–Eriophorum* peat containing remains of sedges and megaspores of *Selaginella*
25–40	Dark brown peat containing burnt *Calluna* stems
40–112	Dry, moderately humified, light brown *Phragmites* peat with burnt *Calluna* stems, seeds of *Carex* sp. and *Menyanthes trifoliata* and megaspores of *Selaginella*
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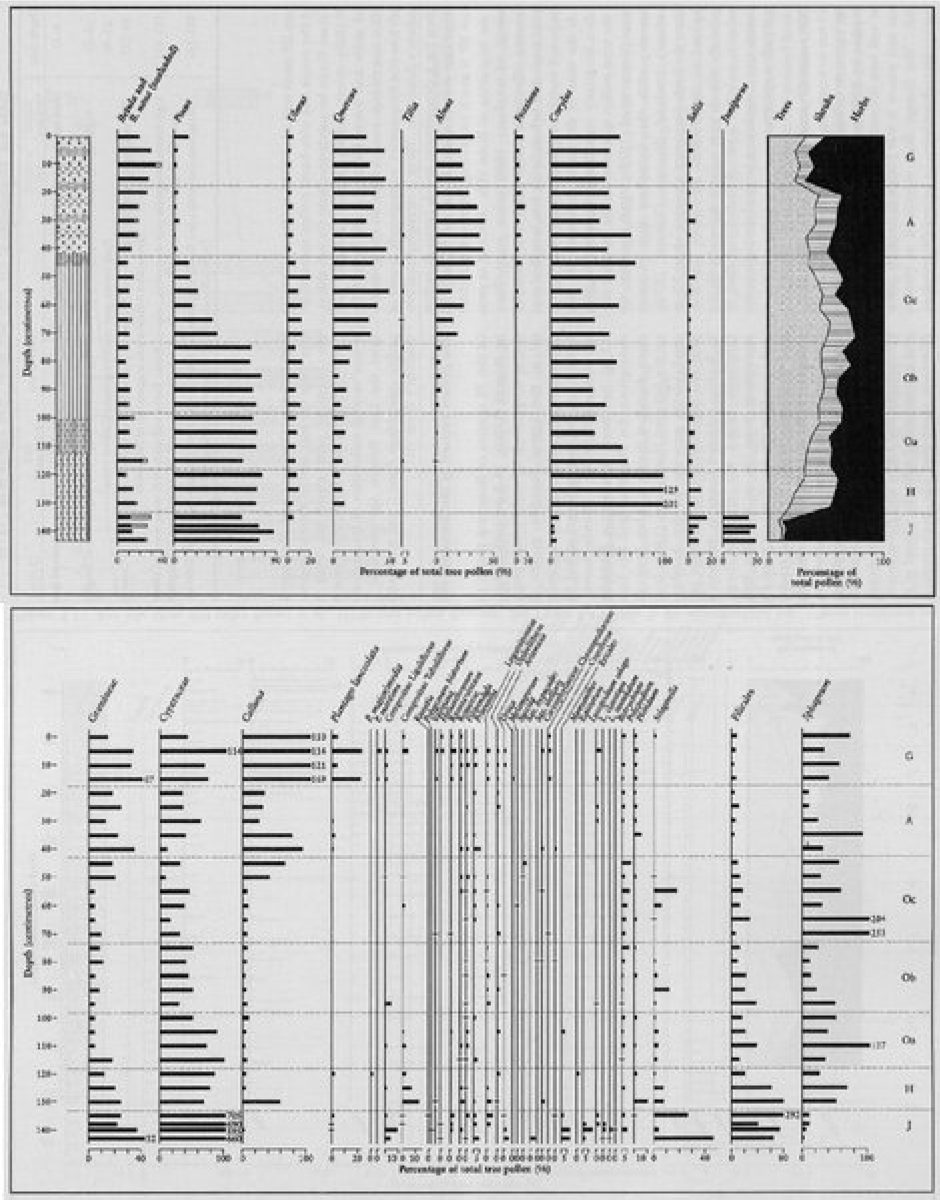
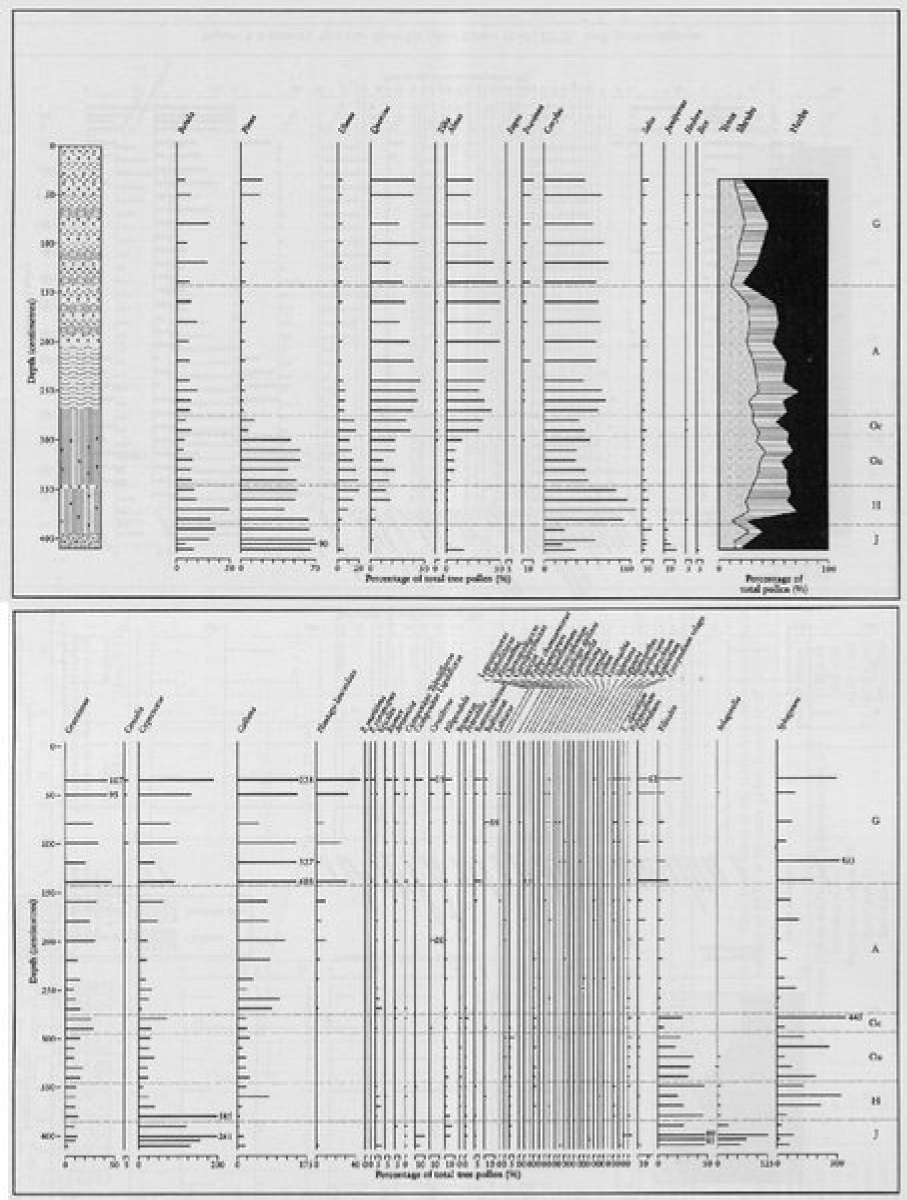
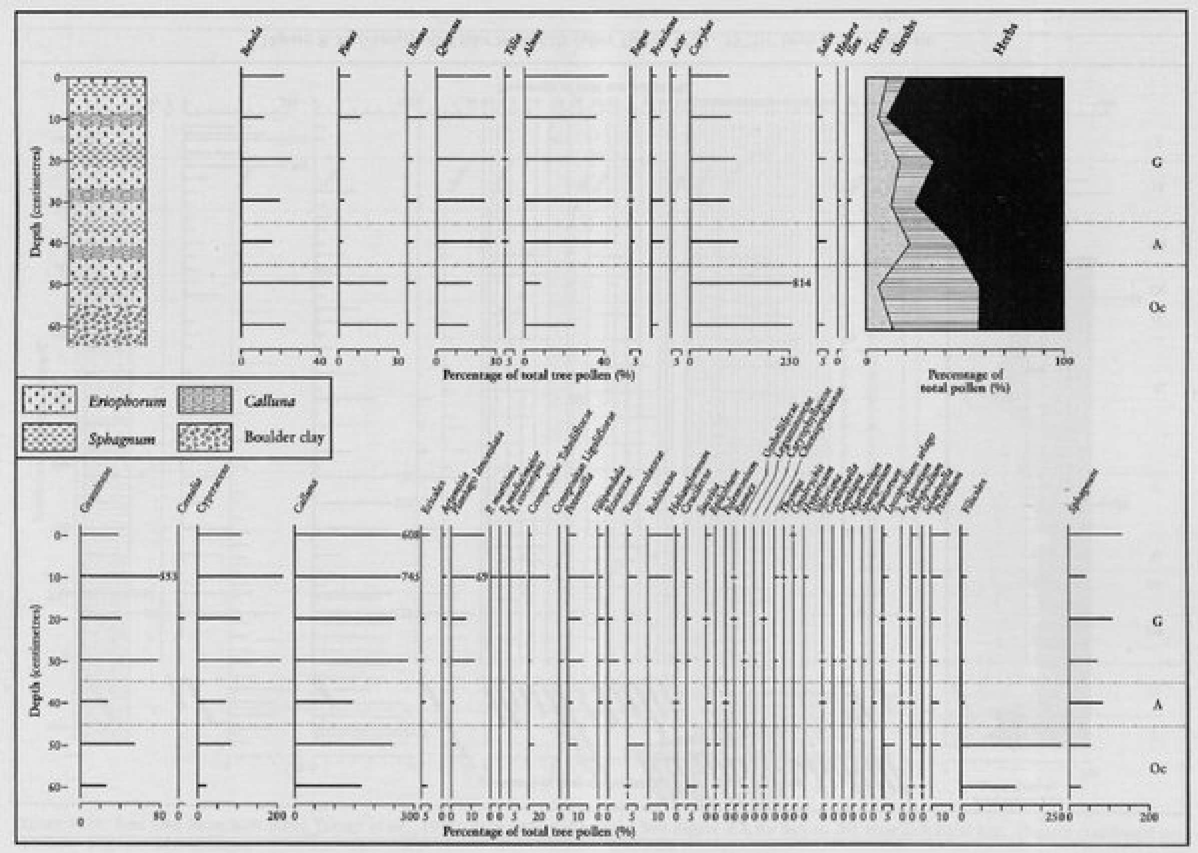
(Table 8.4) Stratigraphy at TSI, Red Sike Moss (after Turner et al.



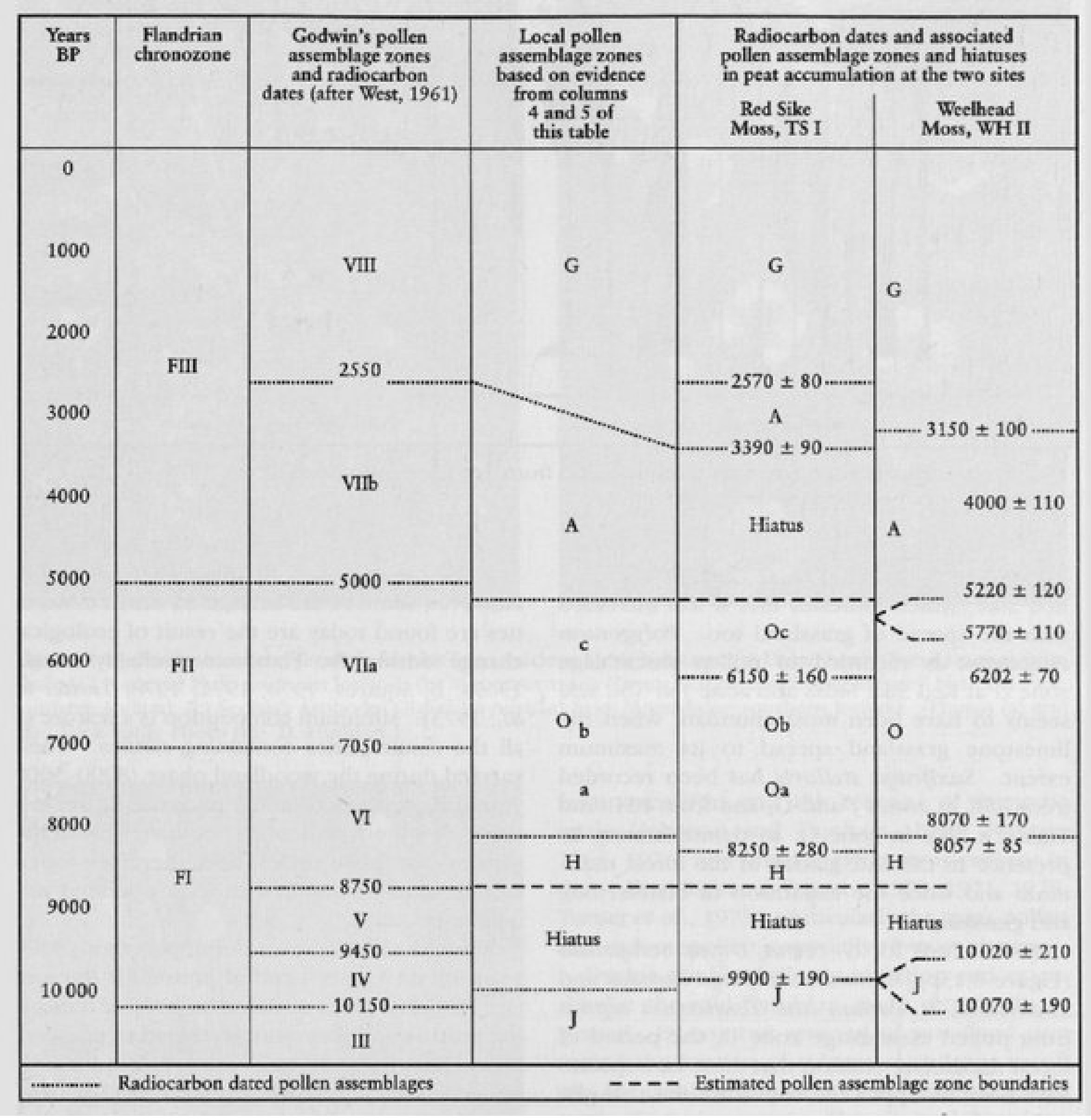
(Figure 8.9) Red Sike Moss TSI (after Turner et al., 1973): herb pollen diagram.



(Figure 8.10) Red Sike Moss RSII (after Turner et al., 1973): tree pollen diagram. See (Figure 8.8) for key to the stratigraphical log. Herb pollen diagram.



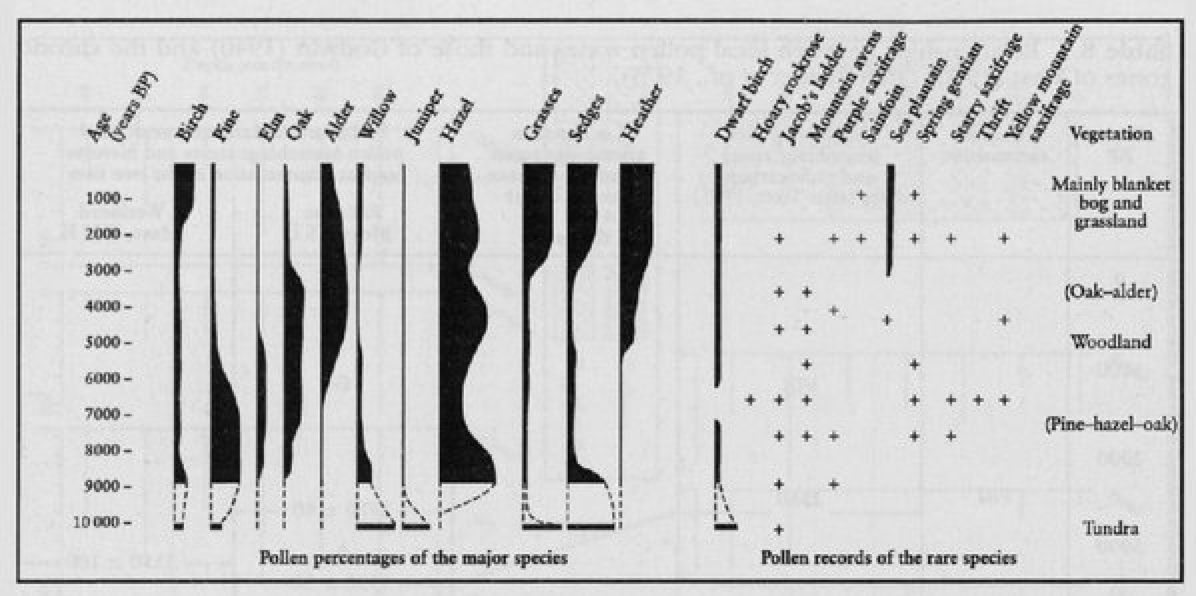
(Figure 8.11) Pollen diagram from blanket peat (BSIII). Frequencies plotted as a percentage of the total tree pollen excluding hazel and willow (after Turner et a1., 1973).



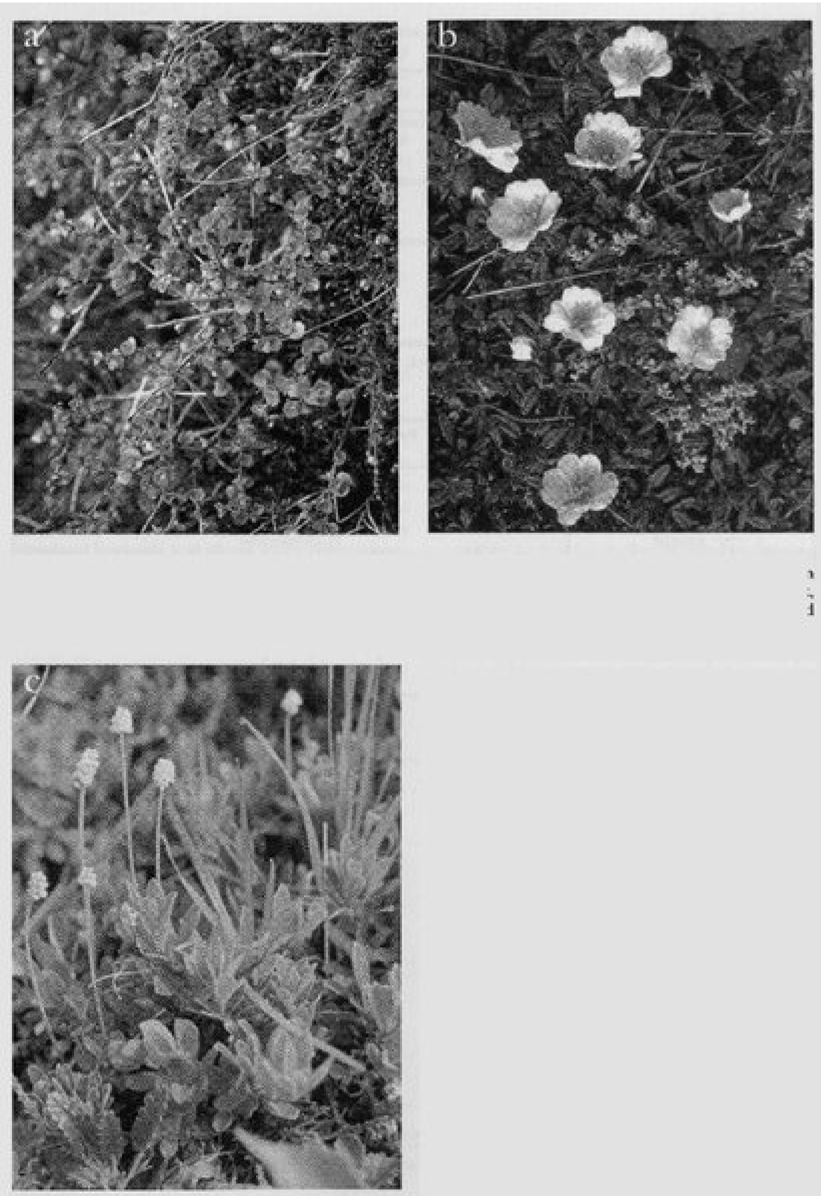
(Table 8.5) Relationships between local pollen zones and those of Godwin (1940) and the chronozones of West (1970) (after Turner et al., 1973)

Laboratory code	Depth (cm)	Pollen horizon	Age, in radiocarbon years BP (before 1950)
GaK-2027	14	Rise in Gramineae *Calluna* and *Plantago*; beginning of zone G	2570 ± 80
GaK-2028	44	Beginning of zone A	3390 ± 90
GaK-2029	70	Beginning of subzone Oc	6150 ± 160
GaK-2030	120	End of zone H	8250 ± 280
GaK-2031	135	End of zone J	9900 ± 190

(Table 8.6) 14 C dates from TSI, Red Sike Moss. They were dated at the Gakushuin laboratory (Japan) and the dates were based on the Libby half-life of 5570 ± 30 years (after Turner et al., 1973)



(Figure 8.12) Summary pollen diagram from Upper Teesdale (after Turner, 1978).



(Figure 8.13) Examples of the Teesdale rarities from modern Arctic habitats: (a) Dwarf birch (Betula nana) from Skaftafell National Park, southern Iceland; (b) Mountain avens (Dryas octopetala) from Skaftafell National Park, southern Iceland; (c) Scottish Asphodel (Tofieldia pusilla) from Morsadalur, southern Iceland. (Photos (a) and (b): Dick Vuijk; Photo (c): D.

Huddart.)

Member of Teesdale assemblage	Geographical element	Taxonomic level of identification	Biostratigraphical position in Teesdale (assemblage zone)
Armeria maritima (Mill.) Willd.	Arctic alpine, maritime	Species	O
Betula nana L.	Arctic alpine	Species	Throughout (J–G)
Dryas octopetala L.	Arctic alpine	Species	O, A
Gentiana verna L.	Arctic alpine, continental	Species	O, G
Plantago maritima L.	Maritime	Species	G
Polemonium caeruleum L.	Continental	Species	Throughout (J–G)
Rubus chamaemorus L.	Arctic alpine, continental	Species	A, G; 3
Saxifraga aizoides L.	Arctic alpine	Species	O, A, G
Polygala amara L.	Continental	Genus	A, G
Polygonum viviparum L.	Arctic alpine	Genus	J, G; 2
Saxifraga stellaris L.	Arctic alpine, continental	Genus	J, O, G; 2
Helianthemum canum (L.) Baumg.	Southern continental	Genus	J, H, O; 2, 3, 4
Thalictrum alpinum L.	Arctic alpine	Genus	Throughout (J–G)
Viola rupestris (Schmidt)	Continental	Genus	O

Schematic Zonation Scheme (Turner *et al.*, 1973)	Possible species other than the one noted
G	*P. vulgaris, P. serpyllifolia*
3000 BP	*P. bistorta*
A	
5000 BP	*S. nivalis, S. tenuis, S. hieraciifolia*
O	
8000 BP	*H. chamaecistus*
H	
10 000 BP	*T. flavum, T. minus* ssp. *minus, T. minus* ssp. *majus*
J	*V. lutea, V. palustris, V. riviniana*

(Table 8.7) Occurrence of Teesdale rarities that possess diagnostic pollen at the species or genus level (after Squires, 1978)