U11
Polytrichum sexangulare-Kiaeria starkei snow-bed

Synonymy
Polytrichetum sexangularis (Rübel 1912) Watson 1925, Br.–Bl. 1926 *sensu* Birse 1984; *Salix herbacea* nodum Poore 1955*c p.p.*; *Polytricheto-Dicranetum starkei* McVean & Ratcliffe 1962.

Constant species
Deschampsia cespitosa, *Kiaeria starkei*, *Oligotrichum hercynicum*, *Polytrichum sexangulare*.

Rare species
Carex lachenalii, *Cerastium cerastoides*, *Luzula arcuata*, *Sibbaldia procumbens*, *Conostomum tetragonum*, *Kiaeria starkei*, *Pohlia ludwigii*, *Polytrichum sexangulare*, *Anthelia juratzkana*, *Moerckia blyttii*, *Pleurocladula albescens*.

Physiognomy
The *Polytrichum sexangulare-Kiaeria starkei* snow-bed brings together a variety of bryophyte-dominated vegetation in which the most consistent species are the montane rarities *Kiaeria starkei* and *Polytrichum sexangulare*, together with *P. alpinum* and *Oligotrichum hercynicum*. *K. starkei* is usually the most abundant of these and, where snow lies particularly late, its yellowish-green shoots can form a virtually pure carpet, but other mosses and hepatics can be locally dominant. *Barbilophozia floerkii*, for example, is often quite abundant in the carpet and sometimes exceeds *K. starkei* in cover, forming extensive dark green patches, and stands rich in *K. falcata* and the rare *Pohlia ludwigii* are also occasionally found. Another uncommon bryophyte, *Pleurocladula albescens*, can occur in some quantity too, the pale colour which gives it its name developing best, according to Watson (1925), where the plants are long deprived of air and light by the snow. Both *Racomitrium heterostichum* and the rare *Conostomum tetragonum* can be moderately abundant, though these species are not so consistently important here as in the various *Salix-Racomitrium* snow-beds.

Other bryophytes which generally contribute to the mat as scattered shoots and small patches include *Racomitrium fasciculare*, *R. lanuginosum*, *R. canescens*, *Pohlia drummondii*, *Nardia scalaris*, *Lophozia sudetica* (perhaps including some *L. wenzelii*) and, more locally, the rare hepatics *Anthelia juratzkana* and *Moerckia blyttii*. Lichens are much less numerous and never abundant, but *Cladonia bellidiflora* and *Cetraria islandica* are quite frequent and *Solorina crocea* is sometimes found.

Vascular plants are typically sparse, although the combination of frequent *Deschampsia cespitosa*, *Carex bigelowii*, *Omalotheca supina* and *Saxifraga stellaris* is very characteristic of this community, the pure white flowers of the last, emerging through the late-melting snow, being one of the most memorable sights of summer botanising in the Highlands. *Huperzia selago*, *Nardus stricta*, *Alchemilla alpina*, *Silene acaulis* and *Sibbaldia procumbens* are also occasional to common, and this kind of vegetation provides one locus for the rarities *Cerastium cerastoides*, *Carex lachenalii* and, sometimes straying from more exposed situations, *Luzula arcuata*. In contrast to the *Salix-Racomitrium* snow-bed, *Salix herbacea* is only occasional and usually of low cover.

Sub-communities

Typical sub-community: In typical stands of the *Polytrichum-Kiaeria* community, *Polytrichum alpinum*, *Conostomum tetragonum*, *Barbilophozia floerkii* and *Racomitrium* spp. are all frequent in the moss carpet and there are occasional records for *Moerkia blyttii*, *Rhytidiadelphus loreus*, *Dicranum fuscescens* as well as *Nardia scalaris*, *Pohlia drummondii*, *Pleurocladula albescens* and *Anthelia juratzkana*. *Cladonia bellidiflora* and *Cetraria islandica* are fairly common and there is sometimes a little *Cladonia pyxidata*, *C. uncialis* and *Solorina crocea*.

Among vascular plants, *Carex bigelowii*, *Omalotheca supina*, *Huperzia selago*, *Nardus stricta* and *Alchemilla alpina* often accompany *Deschampsia cespitosa* and

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Saxifraga stellaris, and there can be occasional *Galium saxatile*, *Silene acaulis*, *Salix herbacea*, *Viola palustris*, *Agrostis capillaris*, *Festuca vivipara*, *Deschampsia flexuosa*, *Juncus trifidus* and *Blechnum spicant*. Even in the more species-rich stands, however, the cover of these species is usually sparse.

Species-poor sub-community

Also included in the community are stands in which the variety of vascular associates is much reduced, often just to scattered shoots of *D. cespitosa* and *S. stellaris*, and the moss carpet very extensive and usually dominated by a single species, generally *K. starkei* but sometimes *Pohlia ludwigii* or *K. falcata*.

Habitat

The *Polytrichum-Kiaeria* community is strictly confined to very late snow-beds at high altitudes through the coldest parts of the Scottish Highlands. It occurs, generally as small stands, in hollows and corries and over sheltered slopes in almost all the major mountain ranges although, towards the more oceanic north-west of Scotland, stands become increasingly local.

This is a vegetation type of some of the highest slopes in the Highlands, characteristic of the middle-alpine zone from around 900 m to over 1200 m. At these levels, annual accumulated temperatures are at their lowest in the country, often less than 250 day-degrees C yr^{-1} (Page 1982), with short, cool summers, mean annual maxima being usually below 21 °C (Conolly & Dahl 1970) and long, bitter winters. These generally harsh conditions are reflected in the floristics of the community in the poor representation of sub-montane plants and the occurrence of many Arctic-Alpines, like *C. bigelowii*, *O. supina*, *S. stellaris*, *Alchemilla alpina*, *Sibbaldia procumbens*, *Silene acaulis*, *Salix herbacea*, *J. trifidus*, *Cerastium cerastoides* and *Carex lachenalii*, and montane bryophytes such as *K. starkei*, *O. hercynicum*, *P. sexangulare*, *P. alpinum*, *C. tetragonum*, *Pohlia drummondii* and *Pleurocladula albescens*.

More particularly, however, this is one of the communities characteristic of more sheltered situations in our coldest mountains where snow is caught and held long into the spring. Across the range of the *Polytrichum-Kiaeria* vegetation, precipitation varies considerably, from not much over 1600 mm with around 180 wet days yr^{-1} in the Cairngorms to the east, to almost 3200 mm with more than 220 wet days yr^{-1} through the western Highlands (*Climatological Atlas* 1952, Ratcliffe 1968). But, at these altitudes, much of the winter share of this is received as snow, with over 100 days of snow- or sleet-fall over the higher ground (Manley 1940), and in the windy conditions this is swept from more exposed ground into sheltered places, accumulating thickly where the gathering grounds are large and persisting long over shaded north- and east-facing aspects. Although detailed data are still lacking, this community seems to be found where such accumulations are deepest and most persistent, not finally melting in some years until well into June. And, though many of the slopes here are quite steep with the melt-waters draining away readily, the ground is generally stable and not much liable to the solifluction or downwash that characterises some snow-beds (McVean & Ratcliffe 1962).

For some of the plants recorded here the snow cover is important in providing shelter from the bitter temperatures and harsh winds of winter. The very occasional ferns such as *Blechnum spicant* and *Cryptogramma crispa*, for example, benefit from the protection from frost, although the ground is generally not sufficiently humic and bouldery for them to thrive in abundance, and snow-lie is altogether too long for the community to provide a locus for those oceanic bryophytes that can persist in less chionophilous heaths (Ratcliffe 1968). More important in this particular case are the redistribution of precipitation through the drifting and persistence of the snow, and the shortening of the growing season by the lengthy snow-lie and irrigation with frigid melt-waters. This combination of factors excludes plants which demand drier ground and/or a longer summer, giving an opportunity for more hydrophilous or competition-sensitive species to flourish. *Salix herbacea*, *Omalotheca supina*, *Saxifraga stellaris* and cushion herbs like *Sibbaldia procumbens* and *Silene acaulis* are among the Arctic-Alpines here which favour more open conditions, while *Deschampsia cespitosa*, *Nardus stricta* and *Carex bigelowii* all tolerate the wet, mineral soils. The moist nature of the ground also enables *Alchemilla alpina* to persist in situations which would otherwise be inhospitable: over higher ground in the Cairngorms, for example, this plant is strongly concentrated around the better-draining sides of these snow patches (Raven & Walters 1956).

It is mixtures of these species which give most of the character to the vascular element of the *Polytrichum-Kiaeria* community, but their contribution to the cover is strictly limited by the luxuriance of the snow-tolerant bryophytes of the community, the plants most obviously able to benefit from the particular environmental conditions here. Not all of the most abundant members of this group are confined to late snow-beds, but *K. starkei*, *K. falcata* and *Racomitrium heterostichum* rarely grow on soil, as opposed to rock surfaces, unless snow-lie is prolonged, and other species of the community, such as *Polytrichum sexangulare*, *Moerckia blyttii* and *Pleurocladula albescens* are virtually exclusive to patches of long-persistent snow (McVean & Ratcliffe 1962). However, some of these do occur in other kinds of chionophilous vegetation, notably in the *Salix-Racomitrium* community and, where the vegetation types occur in

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close proximity, as in the snow-beds of the Cairngorms and Ben Lawers, it is not always clear what environmental factors distinguish them. Sometimes, though, the *Salix-Racomitrium* community does occupy ground where snow-lie is obviously not so deep or lengthy as here, and where the effects of solifluction are more pronounced (McVean & Ratcliffe 1962).

The effects of long-persistent snow override some of the influence of the underlying soils on the vegetation and the *Polytrichum-Kiaeria* community can be found over base-rich substrates, like the calcareous schists of some of the Breadalbane Mountains, as well as more acidic ones. Typically, though, with the strong leaching of the profiles, the soils are base-poor, indeed usually with signs of incipient podzolisation and there is sometimes gleying below where melt-waters produce intermittent waterlogging. A distinct humose topsoil can generally be seen and buried humic layers are sometimes found where wind-blown detritus has been deposited on the vegetation. With surface pH between 4.5 and 5.5, the flora is prevailingly calcifuge or indifferent, *C. bigelowii*, *O. supina*, *Saxifraga stellaris*, *Silene acaulis* and *Huperzia selago* being among the important montane species here with that kind of edaphic preference (McVean & Ratcliffe 1962).

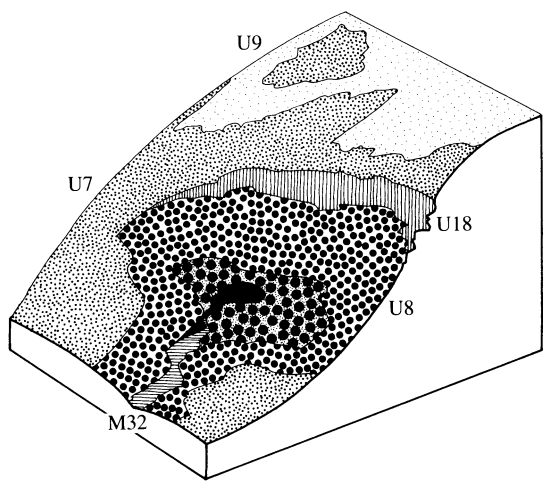
Zonation and succession

The *Polytrichum-Kiaeria* community is usually found as part of suites of chionophilous vegetation types over snow-bound slopes through the middle-alpine zone, where floristic variation can be related to duration of snow-lie, the drainage of melt-waters, the stability of the ground and the base-richness of substrates and irrigating waters. With the geographical shift northwestwards, some elements of these patterns change and the *Polytrichum-Kiaeria* community itself eventually peters out.

The variety and extent of late snow-bed vegetation is greatest of all in the Cairngorms where this and closely-related communities are especially well developed over the north- and east-facing slopes within the transition from the more chionophilous of the *Nardus-Carex* swards to the wind-blasted *Juncus-Racomitrium* fellfield of the summits. Here, hollows and slopes with long-persistent snow can have discrete patches of one or other of the *Polytrichum-Kiaeria* and *Salix-Racomitrium* communities, mixtures of the two occurring zoned over more and less snow-bound and stable ground, or forming intimate mosaics with little apparent relation to topography. The balance in the carpet between such bryophytes as *K. starkei*, *R. heterostichum* and *Gymnomitrion concinnatum* often has to be relied upon to discern boundaries but, with the vagaries of climate from season to season and its sometimes unpredictable effects on the substrate, the disposition of the plants of these communities is not always what might be expected (Poore 1955*c*). And, indeed, we still have so little information about these kinds of vegetation that we remain uncertain how to interpret even the more stable patterns.

The *Polytrichum-Kiaeria* carpets are often sodden with water after the melt, but where distinct springs issue from the snow-beds, patches of the *Pohlietum glacialis* or sometimes the *Sphagno-Anthelietum* can occur, usually clearly marked off by the abundance of their particular dominant bryophytes, the striking apple-green *P. wahlenbergii* var. *glacialis* or the great swollen masses, dull and glaucous, of *A. julacea*. Then, over intermittently irrigated ground fed by such permanent springs or melt-water, there can be stands of the *Alchemilla-Sibbaldia* dwarf-herb community. This shares with the *Polytrichum-Kiaeria* vegetation such species as *D. cespitosa*, *C. bigelowii*, *A. alpina*, *Sibbaldia*, *O. supina*, *Nardus*, *Polytrichum alpinum* and various *Racomitrium* ssp., but *K. starkei* is very scarce there and mosses in general are less abundant than in the snow-bed. Another common feature of many of these patterns in the Cairngorms is the *Cryptogramma-Athyrium* community, also strongly chionophilous, but characteristic of stretches of bouldery ground such as run around the steeper back of snow-beds. The abundance of ferns usually distinguishes such vegetation, but there is sometimes strong continuity with the *Polytrichum-Kiaeria* community through *D. cespitosa*, *S. stellaris* and associated bryophytes (Figure 36).

Figure 36. Complex of vegetation types around a late snow-bed in the Cairngorms.



U7 *Nardus-Carex* grass-heath
U8 *Carex-Polytrichum* sedge-heath and, within, a U11 *Polytrichum-Kiaeria* snow-bed
U9 *Juncus-Racomitrium* rush-heath
U18 *Cryptogramma-Athyrium* fern community
M32 *Philonoto-Saxifragetum* with M33 *Pohlietum* spring at its head

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Surrounding these very distinctive complexes there is often some kind of *Nardus-Carex* heath, sometimes with an intervening zone of *Carex-Polytrichum* vegetation, whose extensive carpets of *P. alpinum* and *Dicranum fuscescens* can give a strong measure of structural continuity to the swards. The *Nardus-Carex* heath, extensive stretches of which can clothe moderately snow-bound slopes, is generally grass- or sedge-dominated, but it can provide fairly gradual transitions from the *Polytrichum-Kiaeria* snow-bed to sub-shrub heaths in the low-alpine zone below and to *Juncus-Racomitrium* fell-field above.

Moving out of the Cairngorms, many elements of these sequences remain important over the highest snowy ground on other mountains through the central Highlands. In some places, later snow-bed vegetation is very well represented, while in others it is less extremely chionophilous communities that predominate and, away from the Cairngorms, the *Carex-Racomitrium* heath replaces the *Juncus-Racomitrium* heath on very exposed plateaus above the snow-beds. But good stands of *Polytrichum-Kiaeria* vegetation can be found with some or all of the other communities mentioned above on Lochnagar, Creag Mhor and Ben Heasgarnich, Ben Lawers, Beinn Laoigh and Ben Alder (Ratcliffe 1977).

Increasingly towards the more oceanic mountains of the north-west, however, the balance among these vegetation types shifts somewhat, with the *Deschampsia-Galium* community becoming ever more important where there is moderately long snow-lie or pronounced irrigation by melt-water. Fragmentary stands of moss-rich *Deschampsia-Galium* snow-beds can be seen in a few places south of the Great Glen, west of Creag Meagaidh and Ben Heasgarnich, but through the Affric–Cannich and Fannich hills and the Monar Forest, this vegetation replaces the *Carex-Polytrichum* heath around the margins of really late snow-patches with the *Polytrichum-Kiaeria* community. There are frequent records for *D. cespitosa*, *C. bigelowii*, *Galium saxatile*, *Polytrichum alpinum* and *R. lanuginosum* throughout these swards, but usually an obvious shift to hypnaceous mosses as dominants in the moss-carpet of the *Deschampsia-Galium* vegetation. Also through the north-west Highlands, grassier stands of this community often extend down below the snow-beds over low-alpine slopes with either a moderate cover of snow or free through-put of melt-water and rain, frequently forming mosaics with chionophilous sub-shrub heaths over bouldery ground or peaty soils. Eventually, in the northern Highlands, the *Polytrichum-Kiaeria* community becomes ever more fragmentary in these complexes and around Ben More Assynt and Foinaven, it is usually mosaics of *Deschampsia-Galium* and *Nardus-Carex* vegetation that constitute the most chionophilous elements of the patterns.

Distribution

The *Polytrichum-Kiaeria* community is the most widely distributed of the late snow-beds, occurring in all the principal ranges of the Highlands north to Beinn Dearg.

Affinities

Watson's (1925) survey of British Arctic-Alpine bryophytes recognised the occurrence of vegetation in the country similar to the *Polytrichetum sexangularis* described by Rübel (1912) from Switzerland, but it was not until the surveys of Poore (1955*c*) and McVean & Ratcliffe (1962) that the communities of our *Schneetalchen* or *Schneeflecken* were characterised in detail. The *Polytricheto-Dicranetum* of McVean & Ratcliffe (1962) forms the basis of the *Polytrichum-Kiaeria* snow-bed, which can also take in samples from Poore's (1955*c*) *Salix herbacea* nodum and the single stand which Birse (1984) allocated to the *Polytrichetum sexangularis* Br.-Bl. 1926.

As understood now, this last association contains pioneer vegetation of the latest Alpine snow-beds with dominant *P. sexangulare* and *Anthelia juratzkana*, two characteristic species here, though rarely abundant, together with *Moerckia blyttii*, *Pleurocladula albsecens*, *Kiaeria starkei* and *Pohlia drummondii* (Oberdorfer 1978, Ellenberg 1978, Matuszkiewicz 1981). Among the wide variety of Scandinavian chionophilous communities, Gjaerevøll (1956) distinguished a *Kiaeria starkei* sociation within the *Polytrichetum sexangularis* abundant in western Norway and Dahl (1956) characterised a *Dicranetum starkei* from Rondane, typical of moist depressions in low-alpine snow-beds with relatively stable ground. These vegetation types, together with our own *Polytrichum-Kiaeria* community, clearly belong in the Salicion herbaceae, the alliance of late snow-beds in the Salicetea herbaceae, a class of generally chionophilous vegetation.

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Floristic table U11

	a	b	11
Kiaeria starkei	V (1–8)	V (1–9)	V (1–9)
Deschampsia cespitosa	V (1–8)	V (1–3)	V (1–8)
Oligotrichum hercynicum	IV (1–4)	IV (1–3)	IV (1–4)
Polytrichum sexangulare	IV (1–6)	V (1–4)	IV (1–6)
Carex bigelowii	IV (1–8)	I (1)	III (1–8)
Polytrichum alpinum	IV (1–9)	I (1)	III (1–9)
Omalotheca supina	IV (1–6)		III (1–6)
Conostomum tetragonum	III (1–4)	I (1)	III (1–4)
Huperzia selago	III (1–3)	I (1)	III (1–3)
Barbilophozia floerkii	III (1–6)		II (1–6)
Racomitrium lanuginosum	III (1–3)		II (1–3)
Nardus stricta	III (1–4)		II (1–4)
Alchemilla alpina	III (1–4)		II (1–4)
Racomitrium heterostichum	III (1–6)	I (1)	II (1–6)
Pohlia nutans	III (1–3)		II (1–3)
Cladonia bellidiflora	III (1–3)		II (1–3)
Racomitrium canescens	II (1–8)		II (1–8)
Galium saxatile	II (1–4)		II (1–4)
Moerckia blyttii	II (1–4)		II (1–4)
Sibbaldia procumbens	II (1–6)		II (1–6)
Silene acaulis	II (1–3)		II (1–3)
Salix herbacea	II (1–4)		II (1–4)
Agrostis capillaris	II (1–3)		II (1–3)
Viola palustris	II (1–3)		II (1–3)
Cetraria islandica	II (1–3)		II (1–3)
Juncus trifidus	II (1–8)		II (1–8)
Rhytidiadelphus loreus	II (1–4)		II (1–4)
Festuca vivipara	II (1–3)		I (1–3)
Deschampsia flexuosa	II (1–3)		I (1–3)
Marsupella emerginata	I (1–4)		I (1–4)
Blechnum spicant	I (1–3)		I (1–3)
Dicranum fuscescens	I (1–3)		I (1–3)
Cladonia pyxidata	I (1–3)		I (1–3)
Solorina crocea	I (1–4)		I (1–4)
Cryptogramma crispa	I (1–3)		I (1–3)
Pleurozium schreberi	I (1–3)		I (1–3)
Cladonia uncialis	I (1–3)		I (1–3)
Empetrum nigrum hermaphroditum	I (1–3)		I (1–3)
Lophozia sudetica	I (1–3)	V (1–4)	II (1–4)
Pohlia ludwigii	I (1)	II (1–6)	I (1–6)
Kiaeria falcata		II (1–6)	I (1–6)
Racomitrium fasciculare	III (1–6)	III (1–3)	III (1–6)
Saxifraga stellaris	III (1–3)	III (1–3)	III (1–3)
Nardia scalaris	III (1–4)	II (1–3)	III (1–4)
Pohlia drummondii	II (1–4)	II (1–3)	II (1–4)

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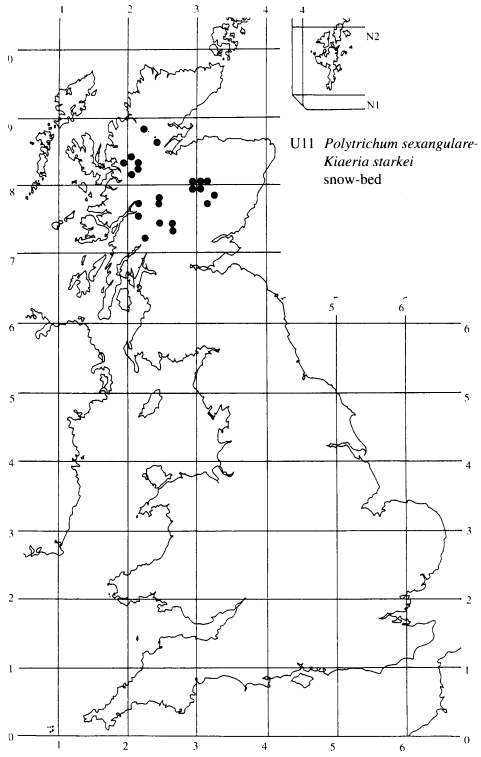
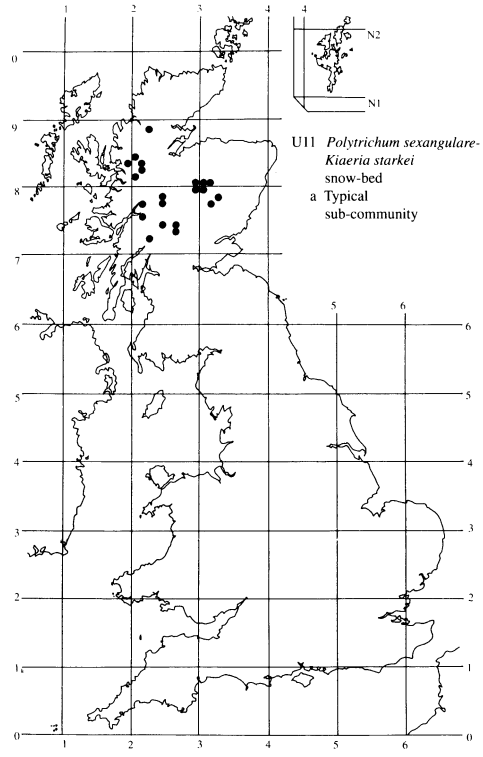
Floristic table U11 (*cont.*)

	a	b	11
Pleurocladula albescens	II (1–4)	II (1–4)	II (1–4)
Anthelia juratzkana	II (1–4)	II (1–4)	II (1–4)
Cerastium cerastoides	I (1)	I (1)	I (1)
Athyrium distentifolium	I (1)	I (1)	I (1)
Number of samples	24	7	31
Number of species/sample	21 (7–33)	13 (8–16)	20 (7–33)
Vegetation height (cm)	6 (2–12)	no data	
Vegetation cover (%)	91 (70–100)	92 (75–100)	91 (70–100)
Altitude (m)	1028 (915–1235)	1061 (915–1082)	1032 (915–1235)
Slope (°)	21 (5–45)	25 (10–30)	22 (5–45)

a Typical sub-community
b Species-poor sub-community
11 *Polytrichum sexangulare-Kiaeria starkei* snow-bed (total)





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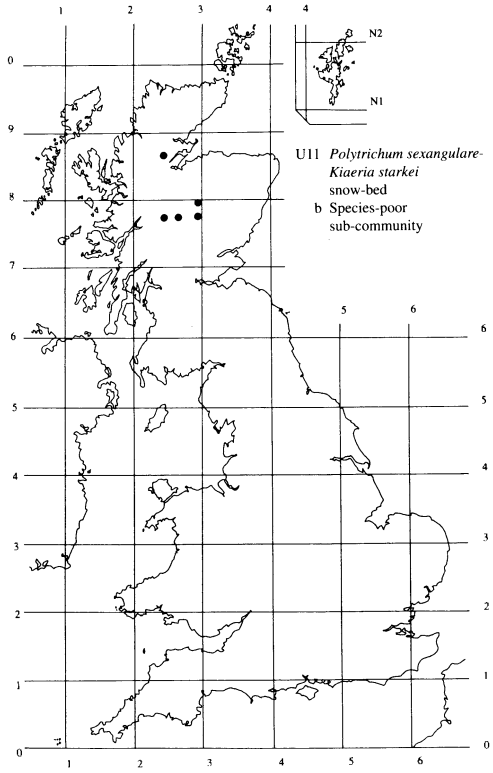

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