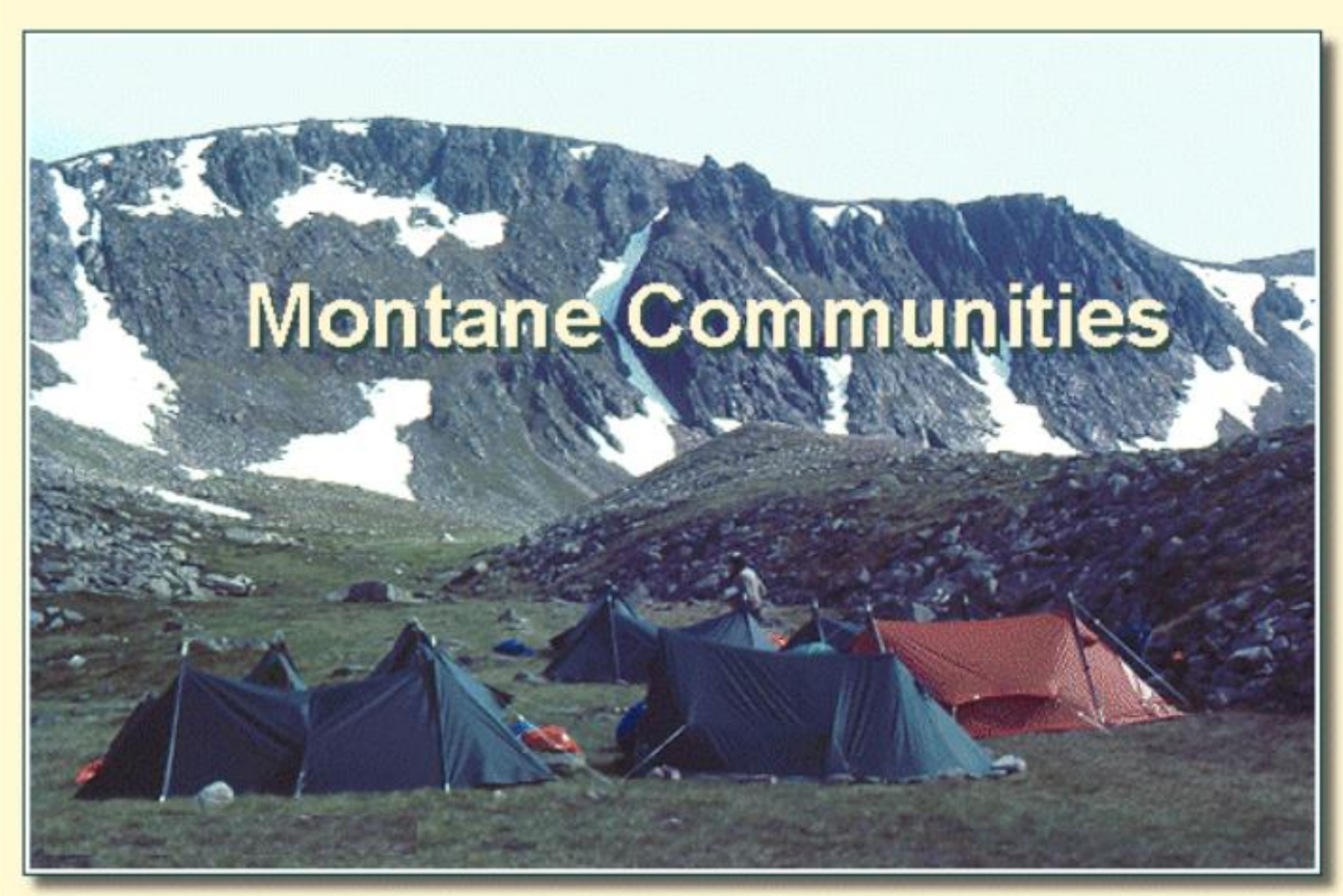
Ecology

of the

British Mountains


Montane Communities

Mountain Vegetation .....

"..... the commonest form of vegetation in the mountains of Britain is some sort of stunted grassland, which with moorland and bog occupy by far the largest area of land and represent the sum of the effects of an inclement climate, a rain washed and leached soil derived in the main from acid soil parent materials, and no doubt a uniformity that has resulted from almost continuous cropping by sheep and deer."

After Pearsall

..... an alternative view .....

"..... it is the existence of such a variety of communities as those of flushed sites, of colonising scree slopes, of exposed summit plateaux and ridges, and of those areas of prolonged snow lie, all maintained by an intimate interrelationship between plant and environment that makes the vegetation of mountains so varied and interesting to study."

After Pearsall

Poore and McVean (1957) considered that most Scottish mountain communities fit into a framework made up of the following five ecological factors:

1. **Altitudinal Zonation**
2. **Oceanicity**
3. **Snow Cover**
4. **Base Status**
5. **Moisture**

- we will consider all of these factors, but
- here we will rearrange them, for each forms part of a factor complex **(mountain environment complex)** which has three main dimensions.

1. **A Climatic Dimension**
2. **A Physiographic Dimension**
3. **An Edaphic Dimension**

- the first two of these dimensions are difficult to separate
- **climate** and **physiography** are factors that are often interrelated at both *meso* and *micro* scales;
- also it is sometimes difficult to separate **physiographic** and **edaphic** effects

The CLIMATIC Dimension.

- mountains and uplands are sharply differentiated in meteorological terms from the lowlands;
- they may be regarded as possessing their own particular **mesoclimate** .... a combination of;
  - low temperatures,
  - severe wind exposure,
  - excessive precipitation cloud and humidity,
  - low evaporation and continuous ground wetness,
  - a deficiency of sunshine and poor visibility,
  - persistent winter frost and snow cover

Meteorological records collected at altitude are particularly scanty, although the Ben Nevis observatory in the early part of the century, the Caingorm weather survey in the 1950's, and more recently the Institute of Hydrology and the Heriot-Watt University automatic weather stations on the summit of Cairngorm itself, as well as installations associated with the Scottish skiing industry have provided some information.

Institute of Hydrology automatic weather station, Cairngorm summit

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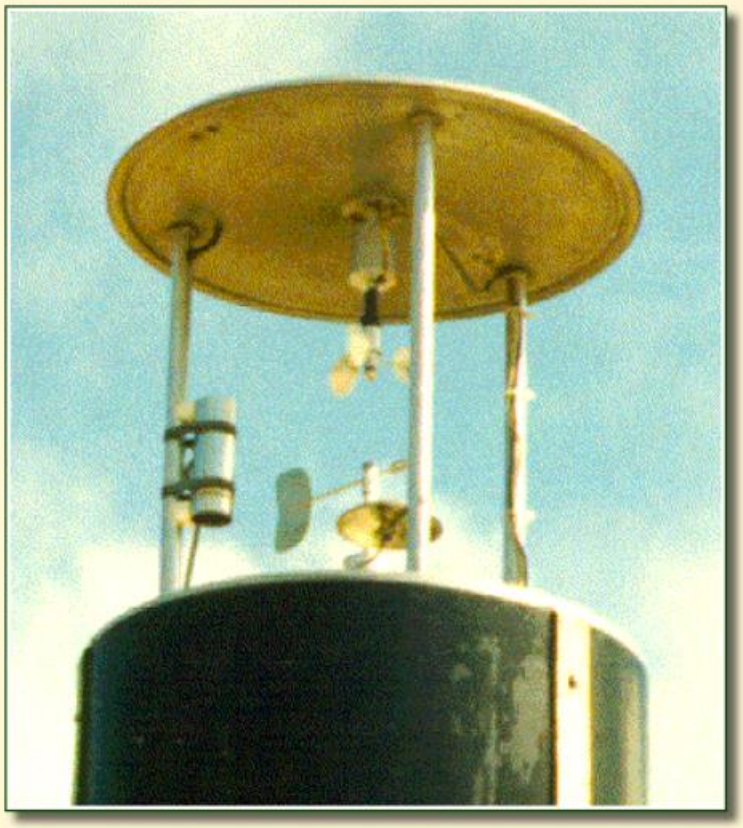
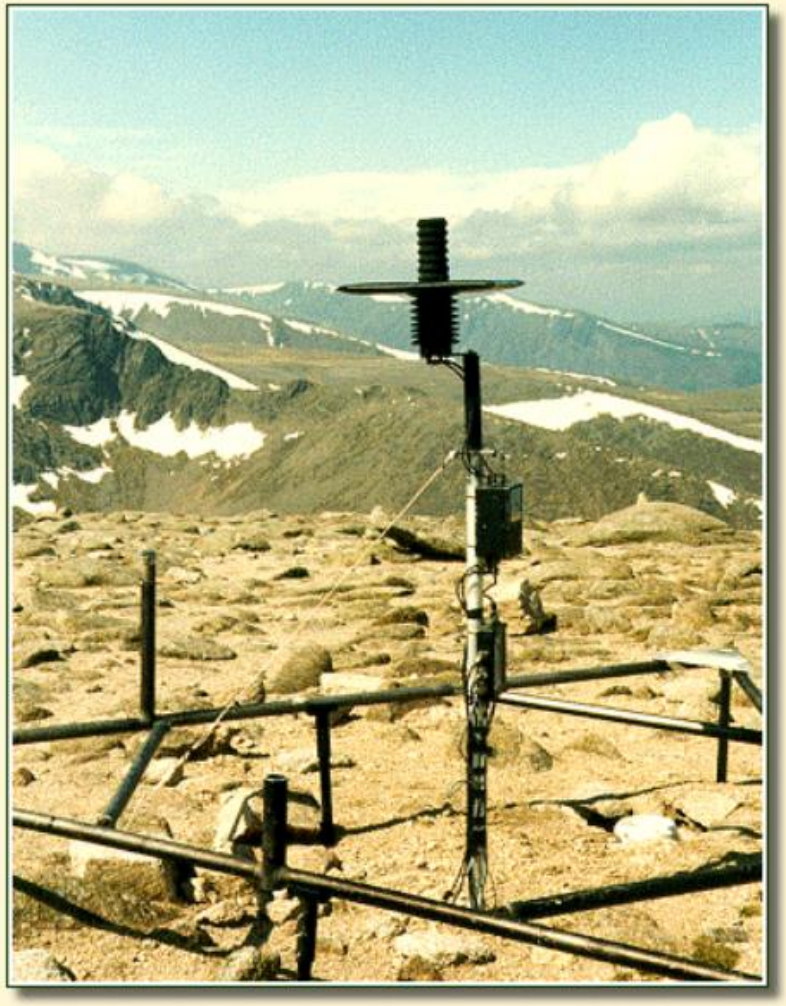


Institute of Hydrology Automatic Weather Station: instruments emerge from the protective cylinder every fifteen minutes to take readings. The rim of the cylinder is equipped with a heating ring to overcome rime and icing up in winter.

Heriot-Watt University automatic weather station, Cairngorm summit



Heriot-Watt University
automatic weather station,
Cairngorm summit

Heriot Watt University Automatic Weather Station: the instruments were originally mounted on the corners of the tubular frame seen at the bottom of the picture. This was periodically struck by a hydraulic hammer to overcome rime and icing up in winter. However the only active instruments at the time of this picture are mounted on the central pole.

Radiation.

- mean standard radiation increase with altitude of about 10% /1000m;
- partially compensated by summer season radiation receipts
- offset by ground conditions which delay soil warming until late summer, especially in wet, peaty, or snowlie areas

Temperature

- a standard lapse rate of mean temperature of 6 degrees Celcius/1000m
- lapse rate of maximum temperatures is greater, 8-10 degrees Celcius/1000m
- temperature variation in the mountains is much greater than in the lowlands
- wind is a climatic parameter of the profoundest importance in the mountain environment
- shelter and exposure, becomes critically important as does the accumulation of snow

Precipitation.

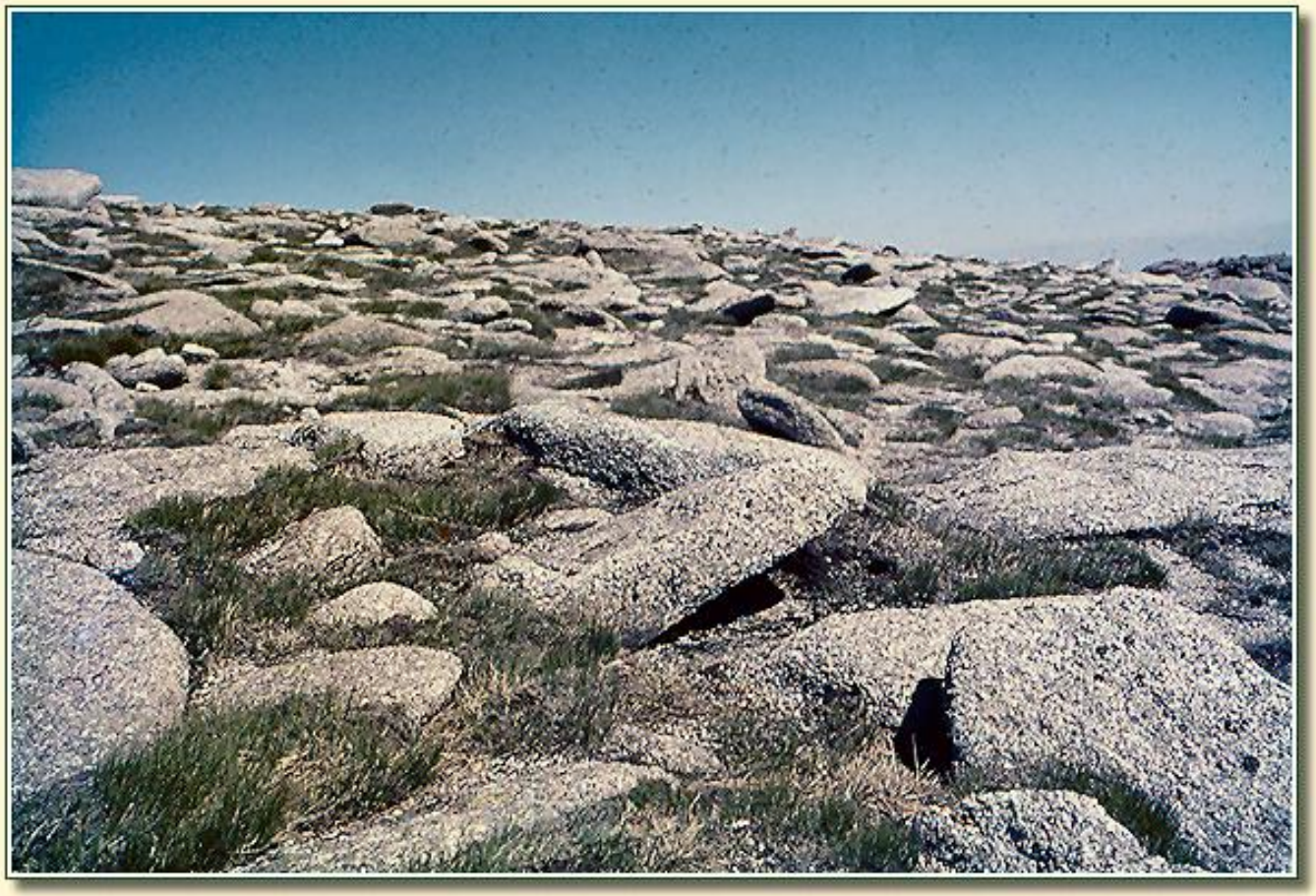
- precipitation increases with altitude (dominant components of rainfall are **cyclonic** and **orographic**)
- **cloud cover** and atmospheric **humidity** also tend to increase with altitude contributing to the wetness of the environment
- **radiation inputs** are much reduced, and diurnal and seasonal warming are seriously delayed and surface and air temperature ranges reduced
- **sunshine quantities** are reduced especially in late summer and early autumn.
- **snow frequency** and **intensity**, the risk of blizzards and prolonged snow cover, also increase, while the length of the frost free season decreases
- **snow lie** has a number of significant effects on plant growth and ecology

Oceanicity.

- climate is influenced by the effect of the surrounding seas
- maritime effect is recognised in the concept of oceanicity
- the index of oceanicity increases westwards with maximum values along the western Atlantic seaboard,
- the east central Highlands are markedly more continental

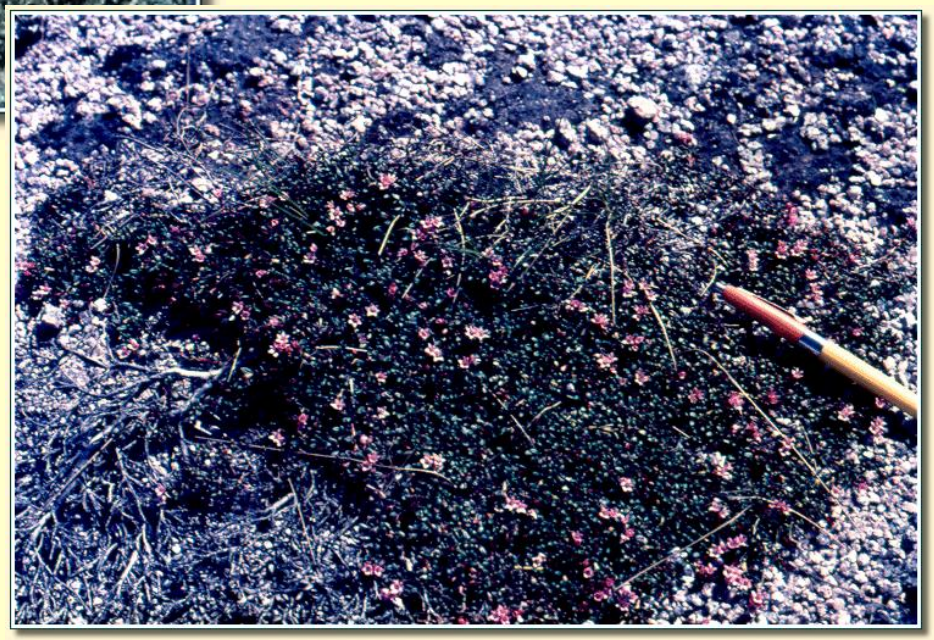
Response of Plants and Animals to the Mountain Bioclimate:

- tree and shrub species disappear as altitude increases,
- low growing plants with **prostrate, rosette, cushion**, and carpet growth habits are prevalent
- intimate relationship between vegetation and the site factors of **shelter** and **exposure**
- high **evapotranspiration** losses due to wind, high insolation in summer, and freely draining substrates
- great reduction in **growing season** and reproductive adaptations
- **chionophilous** *(benefiting from snow cover)* and **chionophobus** *(snow cover detrimental)* relationships with snow lie

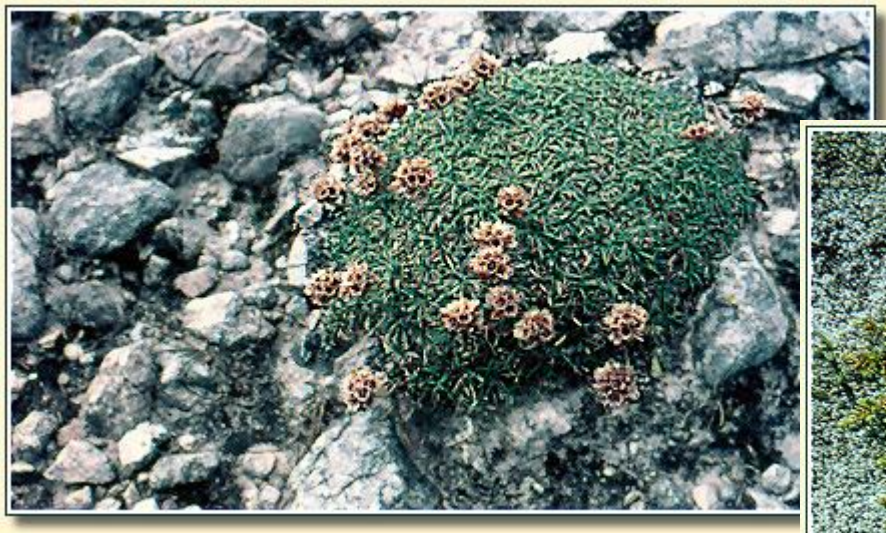


Boulder field of granite core stones on the Cairngorm plateau forming a mosaic of sheltered and exposed sub habitats exploited by the three leaved rush ***Juncus trifidus*** and other montane plants

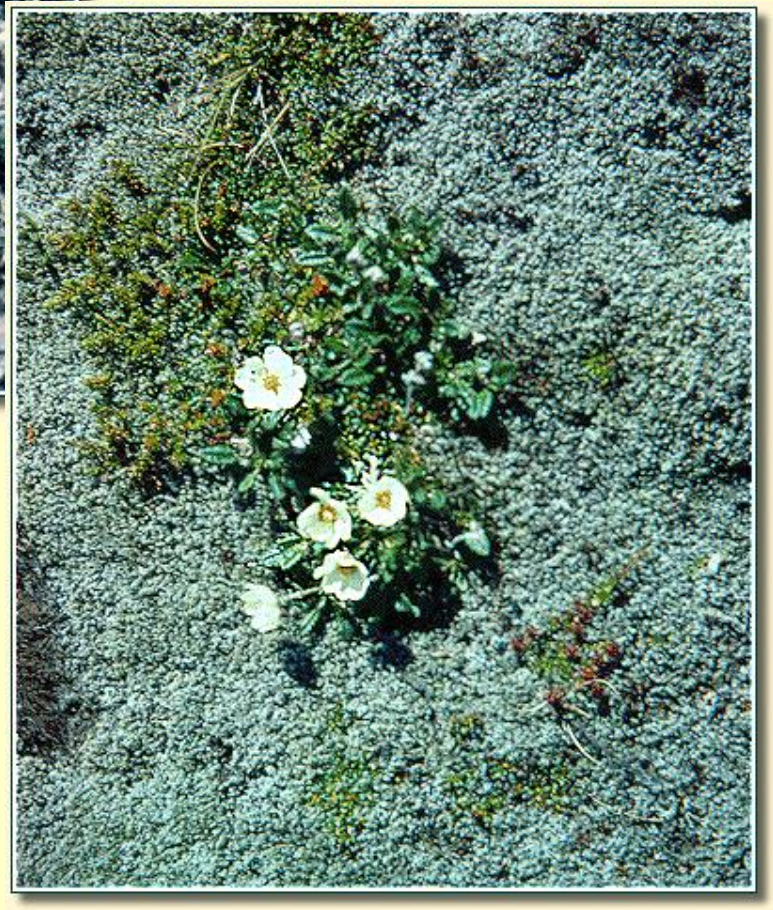
cushion herb habit: ***Armeria maritima***



prostrate chamaephyte habit: ***Louiseleuria procumbens***



cushion herb habit: ***Armeria maritima***

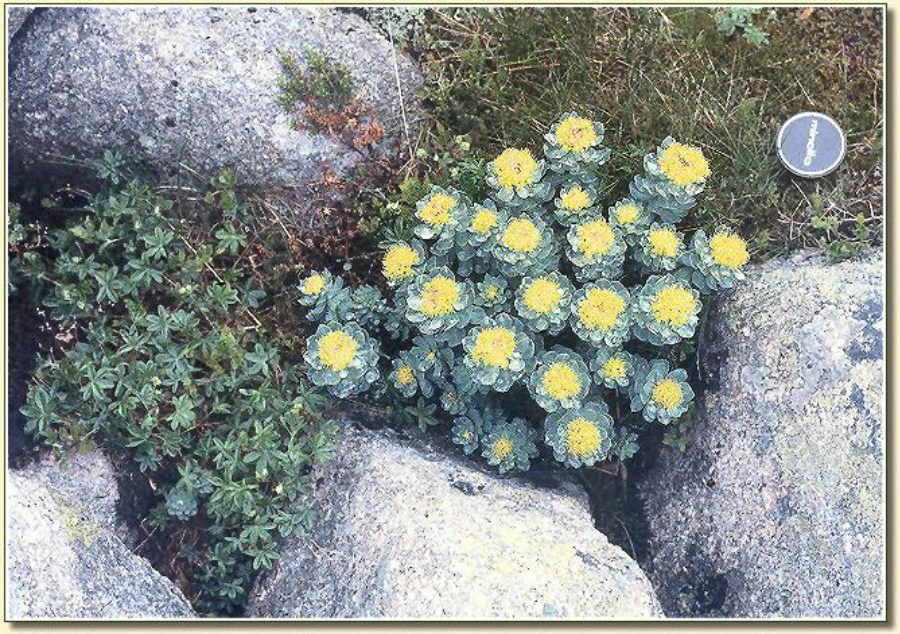


prostrate chamaephyte habit:
Empetrum hermaphroditum, and
Dryas octapetela in moss carpet of
Rhacomitrium lanuginosum

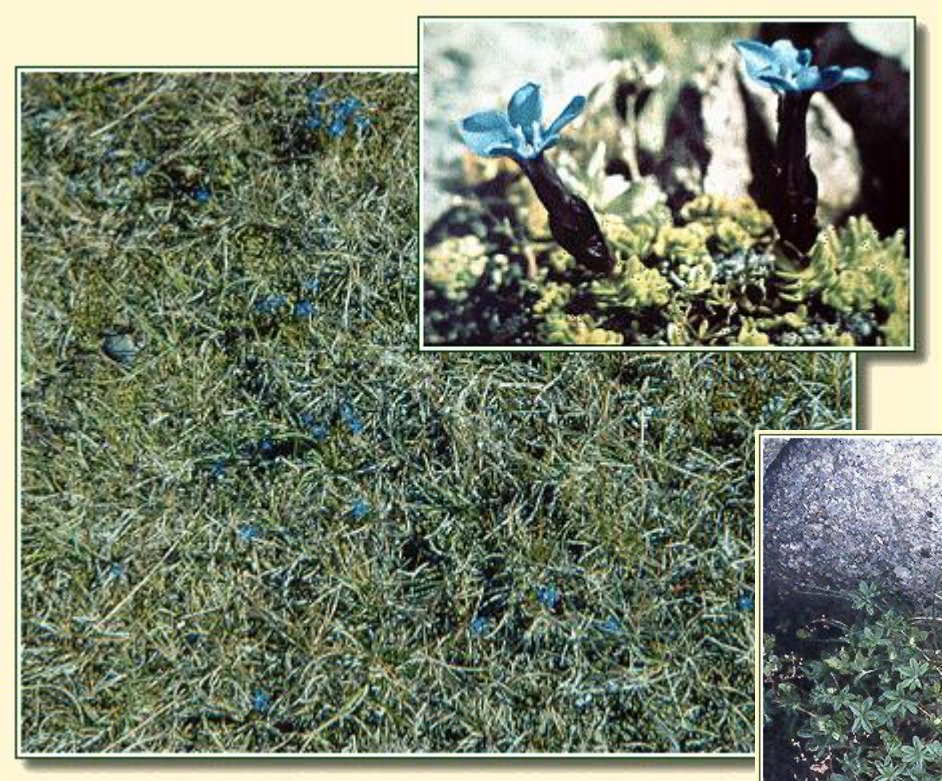
prostrate chamaephyte / nano phanerophyte habit:
Arctostaphylos uva-ursi

Prostrate montane dwarf shrub species crowberry, bearberry and bilberry forming a distinct pattern responding to wind erosion, ablation of and inundation by granite grit on an exposed summit ridge by growing forward in a down wind direction.

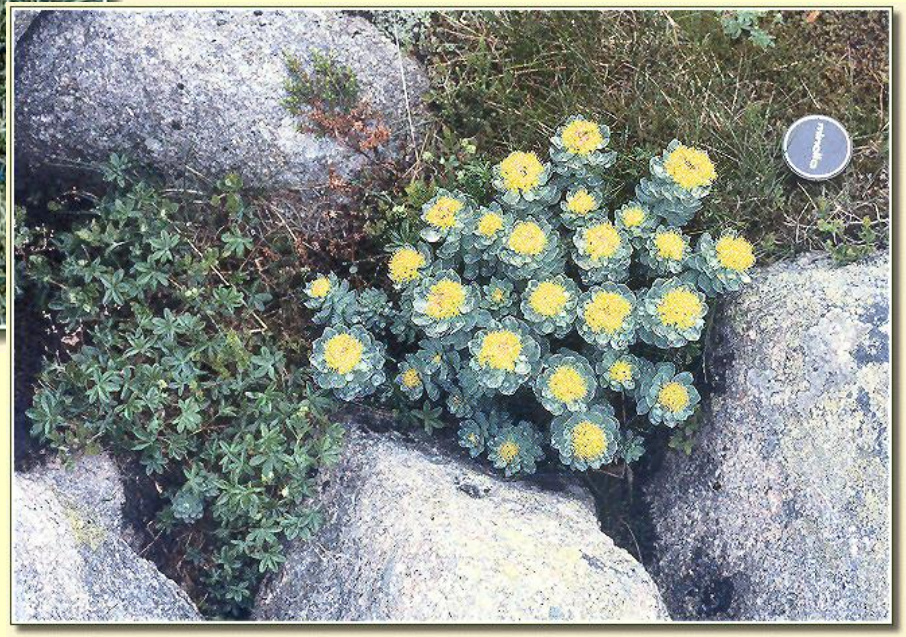
prostrate chamaephyte / nano phanerophyte habit: ***Arctostaphylos uva-ursi***



Rhodiola rosea in shelter of bloulder field



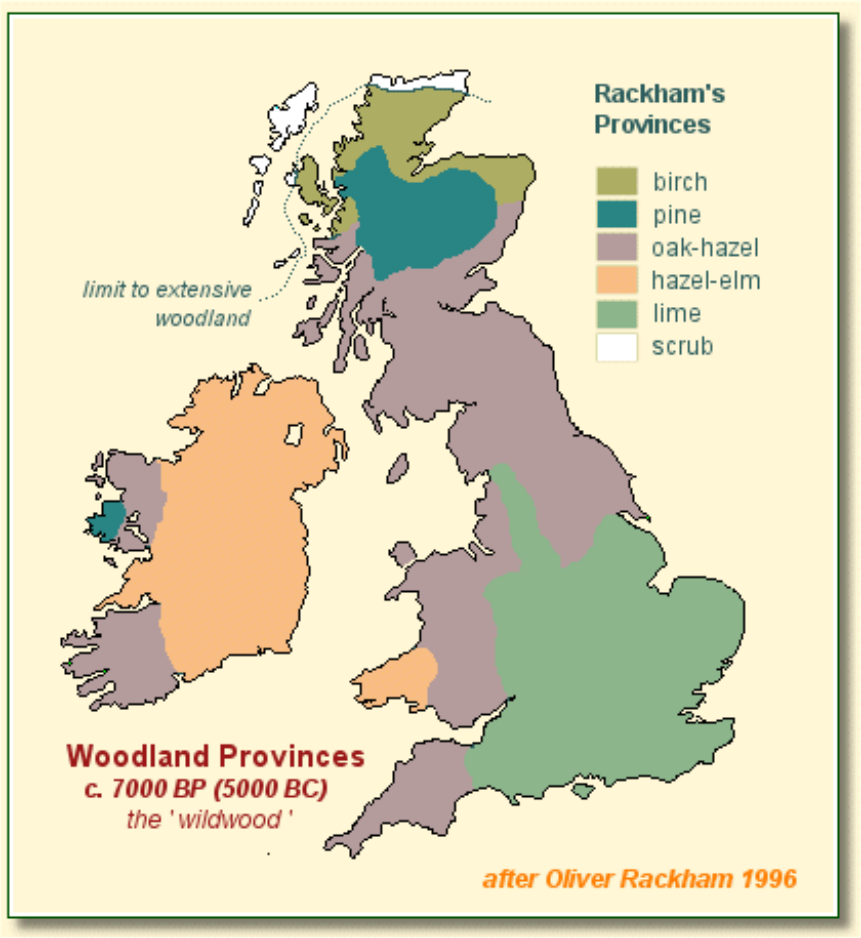
Gentiana verna, an example of a rosette chamaephyte



Rhodiola rosea in shelter of bloulder field

Altitudinal Zonation of Vegetation and Climate:

- There are two axes of variation in British woodland ecosystems, both of which are complex.
- First there is a **(Phyto)Geographical**, axis largely climatically determined and then a second or **Edaphic axis,** controlled by soil characteristics and drainage.
- The **(Phyto)Geographical** axis has a **latitudinal** component running from southeast to northwest and an **altitudinal** component with both the structure and composition of the canopy and ground flora changing with increasing altitude,



Everywhere in the British Isles where tree growth is not precluded by local ecological conditions, or by altitude the climatic climax vegetation is some kind of deciduous, mixed, or coniferous woodland ecosystem reflecting in its variation the two axes just alluded to. In Scotland in the East/Central Highlands this ecosystem is **Native Pine Woodland**

Altitudinal Zonation of Vegetation and Climate:

- the theoretical datum line of such mountain *zonations* is the climatic **forest limit**, or **altitudinal treeline**
- actually two lines .... the forest limit, or **timberline**, and the **treeline**
- and a **zone of transition** or **ecotone** between them
- here trees thin out growing as small groups or as scattered individuals, often showing **dwarfed, semi-prostrate, flagform** or **krummholz** growth habits

Although becoming smaller in stature with increasing altitude these pines are still showing a normal tree growth habit and are present at a normal forest density.

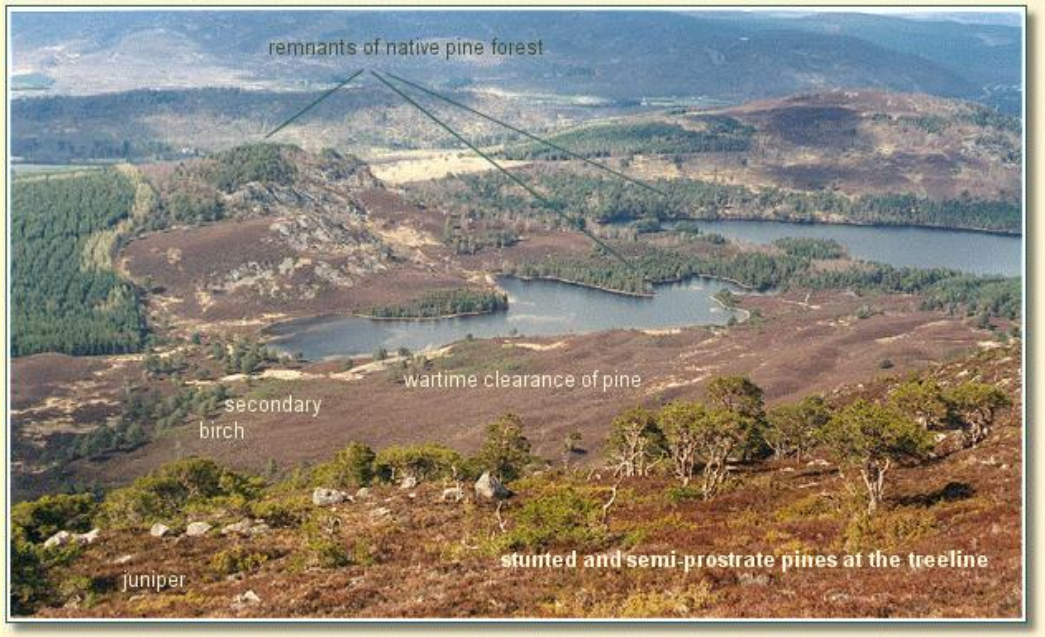
The altitude at which these characteristics cease to be present forms the **timberline**

High climbing pines on the slopes of Creag Fhiaclach, Glen Feshie, in the Cairngorms

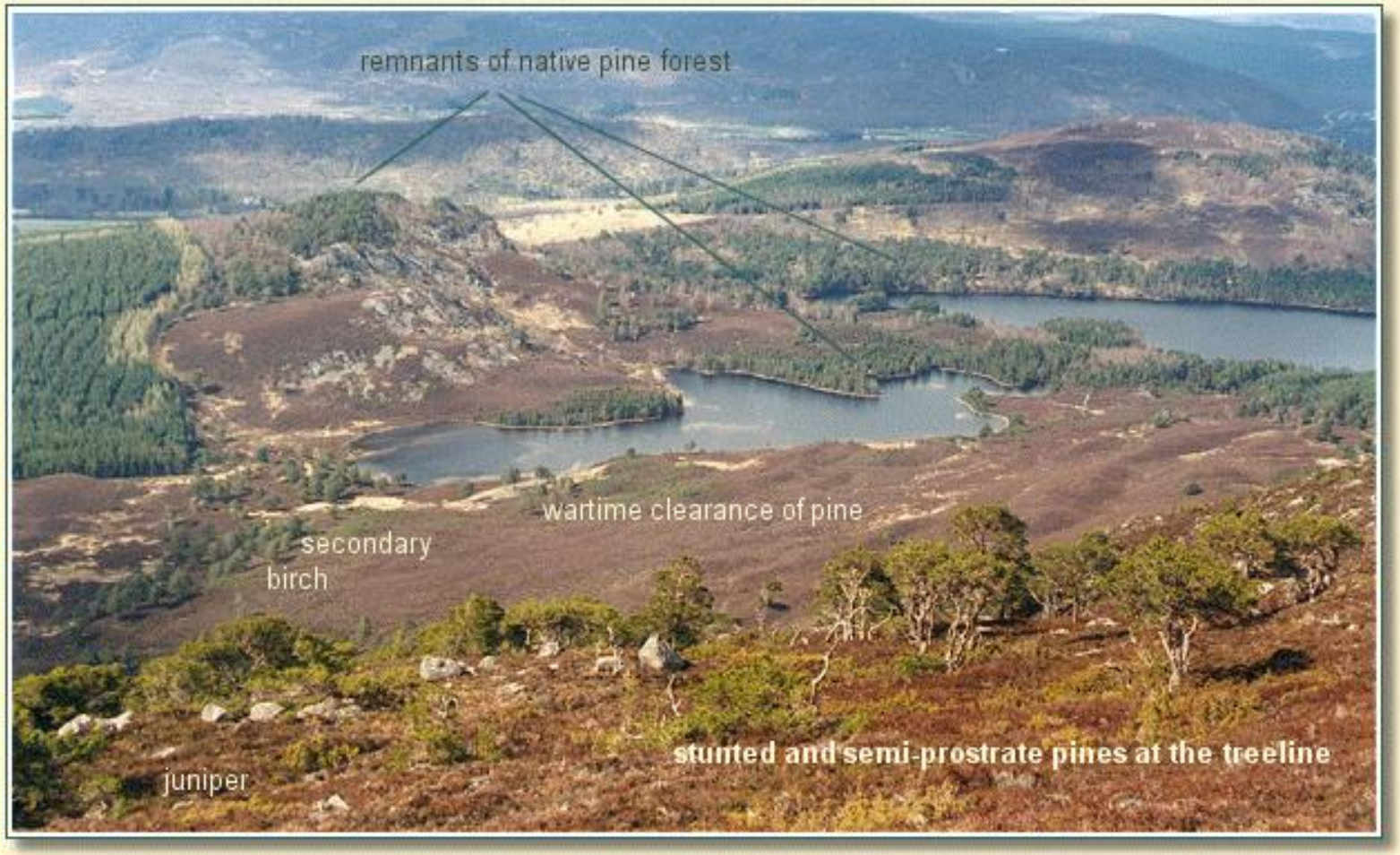
- difficult to establish either the natural climatic forest limit, or the **potential treeline** in Scotland,
- forest has been cleared and where treelines exist they display none of the features of natural timber or treelines
- they occur at lower altitudes than would be the case under natural conditions because of anthropogenic interference

- An example of an artificial “treeline” on the slopes of Cairngorm

Community Ecology & Conservation



- the only really natural treeline in the Highlands occurs at c. 640m at **Creag Fhiaclach** in the Cairngorms
- beyond is a distinct **Sub-Alpine Zone** of juniper scrub that appears to have escaped the burning that presumably destroyed it elsewhere


remnants of native pine forest
wartime clearance of pine
secondary birch
juniper
stunted and semi-prostrate pines at the treeline

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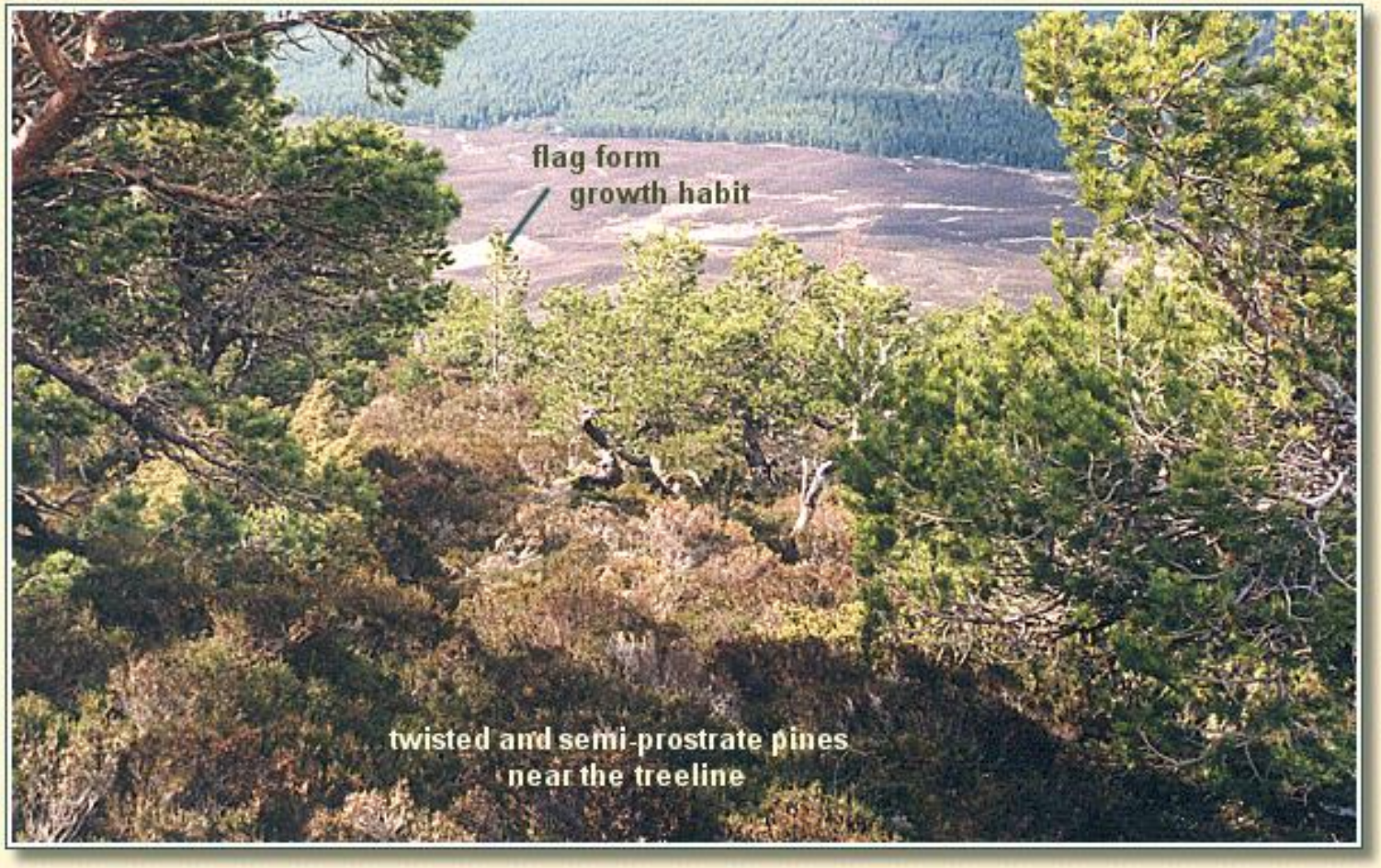

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Sub-Alpine Shrub Zone in Scotland

- juniper scrub on the well drained acid hills of the east and central Highlands.
- willows (***Salix lanata***, ***S. lapponum***, ***S. myrsinites***, ***S. aurita S. repens***) on wetter and more eutrophic soils. nb. good example of such willow scrub on Durness Limestone in Inchnadamph.
- dwarf juniper scrub (***Juniperus communis spp nana***) on the Torridonian sandstone, Cambrian Quartzites, and granites of the west and north.
- the dwarf birch, ***Betula nana***, may have been an important constituent of the scrub growing on bogs in this **Sub-Alpine Zone**

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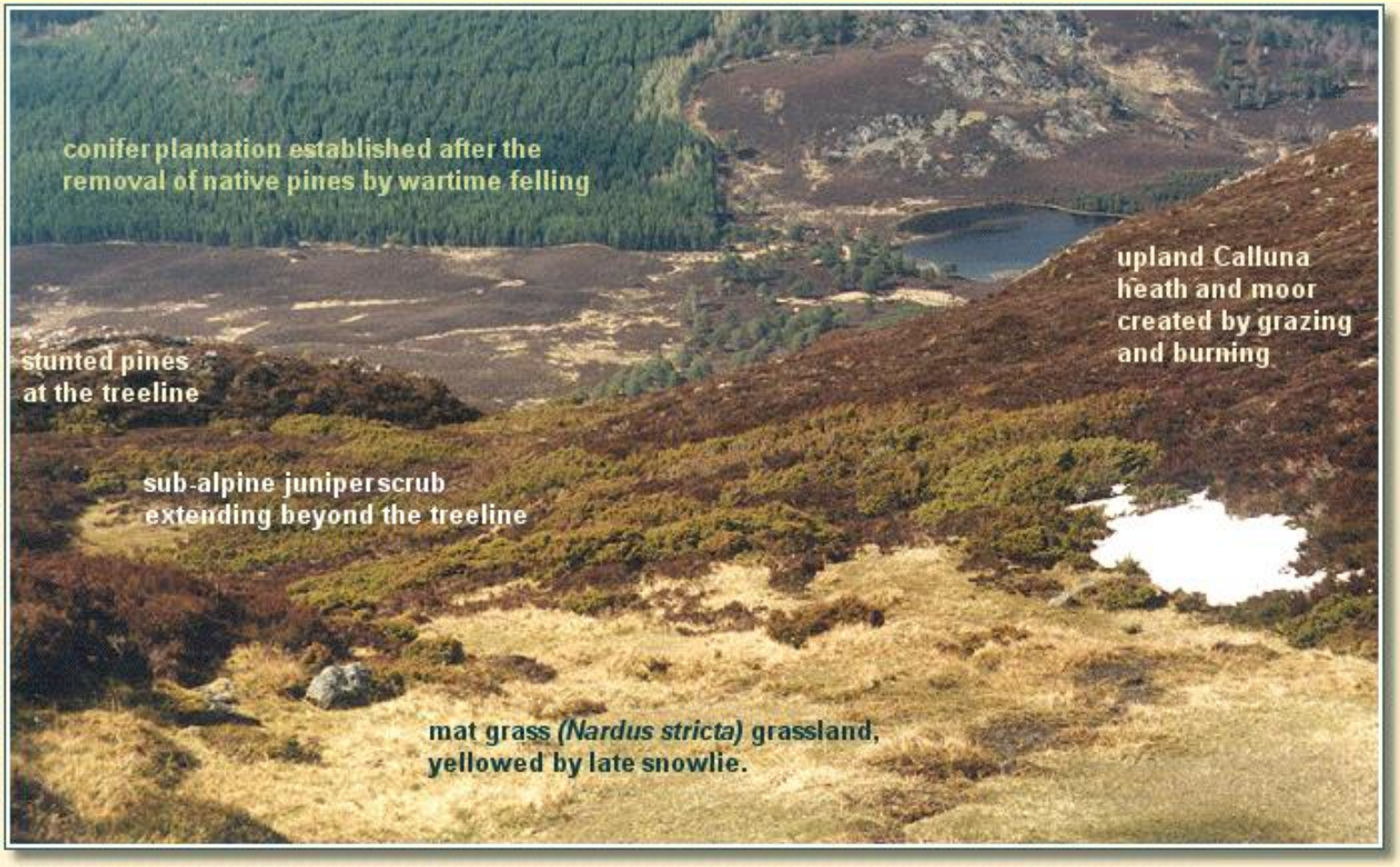

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The overall altitudinal zonation of vegetation in the Scottish Highlands can be summarised as follows:

I. SUB ALPINE ZONE
Potential birchwood, birch scrub, juniper, or willow scrub. Now: ***Calluna*** moor ***Festuca/Agrostis,*** ***Nardus***, and/or ***Trichophorum/Molinia*** Grassland, or Blanket bog.

III MIDDLE ALPINE ZONE

Juncus trifidus heaths ***Festuca vivipara/Gymnomitrium*** communities.
Snowbed communities.

II LOW ALPINE ZONE

b. Moss Sub-Zone

Dwarf shrubs still present. ***Rhacomitrium*** 'heaths', ***Empetrum/Vaccinium*** communities.

a. Dwarf Shrub Sub-Zone

Ericoid dwarf shrub heath, rarely dwarf juniper, birch, or willow scrub.

- the altitudinal limits of these zones become depressed towards more westerly and more northerly sites
- the zones become simultaneously wider, so that the **Low Alpine Zone** in particular becomes more important in Scotland than in Norway
- this is because of the depression of the treeline due to increased exposure, the great extension in bog covered ground, and because of the relatively higher altitude at which temperature becomes limiting for dwarf shrub growth

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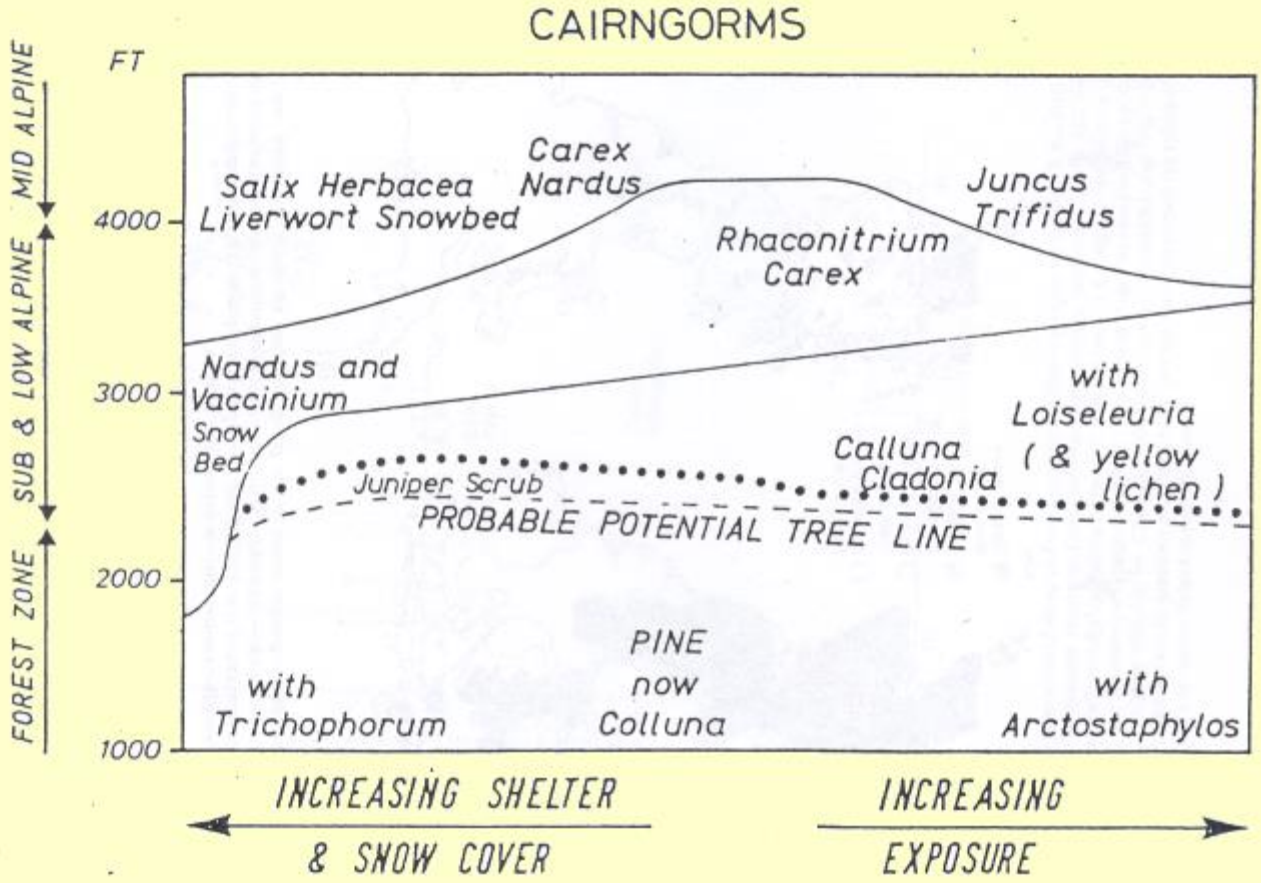

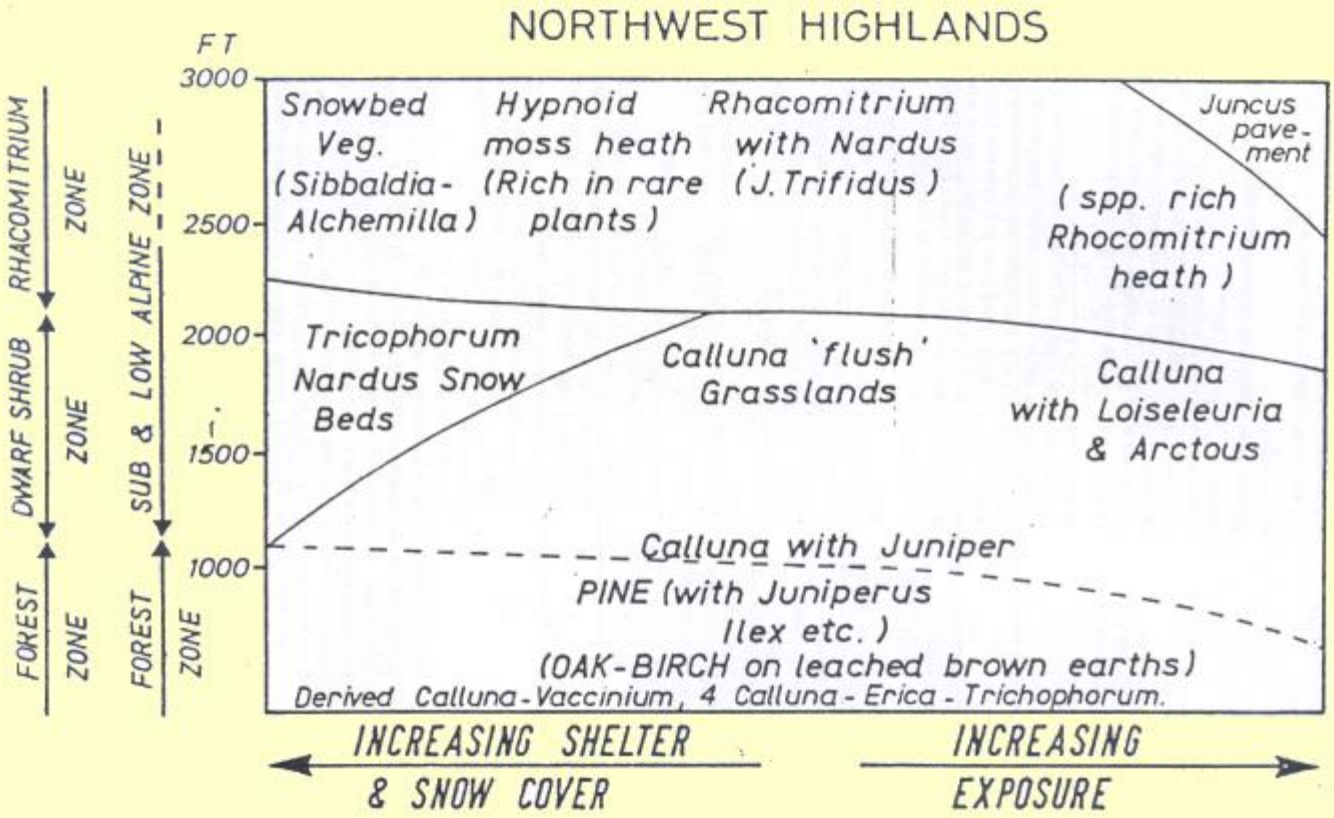
NORTHWEST HIGHLANDS
FT
3000
2500
2000
1500
1000
RHACOMITRIUM ZONE
DWARF SHRUB ZONE
SUB & LOW ALPINE ZONE
FOREST ZONE
FOREST ZONE
Snowbed Veg. (Sibbaldia-Alchemilla)
Hypnoid moss heath (Rich in rare plants)
Rhacomitrium with Nardus (J. Trifidus)
Juncus pave-ment
(spp. rich Rhocomitrium heath)
Tricophorum Nardus Snow Beds
Calluna 'flush' Grasslands
Calluna with Loiseleuria & Arctous
Calluna with Juniper
PINE (with Juniperus Ilex etc.)
(OAK-BIRCH on leached brown earths)
Derived Calluna-Vaccinium, & Calluna-Erica-Trichophorum.
INCREASING SHELTER & SNOW COVER
INCREASING EXPOSURE

The PHYSIOGRAPHIC Dimension.

- acts through climate, through soils, and through drainage regime
- these effects can best be considered at different scales: as due to either macro, or micro relief or topography

Microtopography:

- microtopographic variation is expressed through the relative degrees of shelter and exposure provided by any particular site, and operates mainly through the microclimatic growth environment of the individual plant.
- specific topographic features form particular and specialised habitats for plant growth: ledges & fissures, blockfields, scree slopes and boulder slides, solifluction terraces, patterned ground, seepage lines & wet flushes

Macrotopography:

- effects the overall **mesoclimate** of a mountain massif
- **geomorphological** character of mountain **physiography**
- leads to distinct **landform suites** and **types of landscape**
- significance of these contrasts in mountain scenery lies in their effect on the **areal extent** of different habitats and hence plant communities.
- interaction of **slope angle**, **length** and **orientation** on aspect
- also controls the development of **'katabatic'** and **'anabatic'** diurnal patterns of air movement

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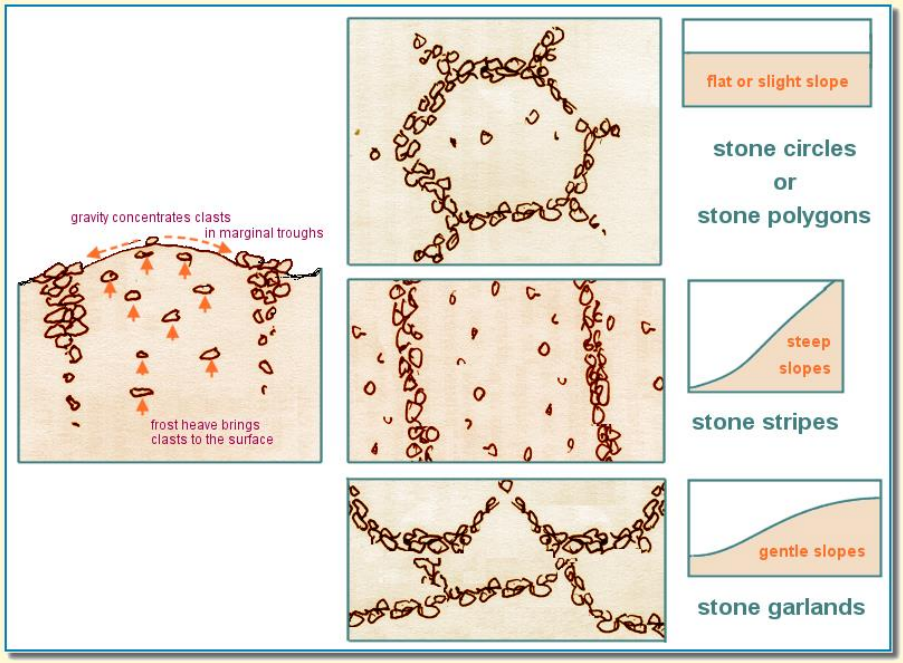
The EDAPHIC Dimension.

mountain soils mainly reflect the dominant influence of the climatic and parent material factors of soil formation

- influence of the former is to affect the rate of weathering, to control the potential for leaching and translocation, and to act through the occurrence of waterlogging to influence the accumulation of organic matter
- western and northern distribution of mountains in the British Isles coincides more or less with the distribution of the older, more resistant, siliceous, and acidic rock types and these dominate as sources of parent material for soil development
- deeper soil profiles are mainly associated with glacial, fluvio-glacial, and periglacial superficial materials derived from these rocks

- base rich soils are maintained largely by irrigation ***(flushing)*** with water that is strongly charged with ions removed from the rock and/or other soil by leaching, and by through flow,
- or by mechanical instability due to gravity ***(screes, talus, colluvium),***
- or to **soil frost phenomena** producing sorting, mixing, heave, and movement ***(geliturbation, solifluction)***
- on any one parent material, therefore, most differences in **soil base status** are due to the varying incidence of such enrichment processes.
- even on **base rich** rocks leaching usually produces **base difficient soils** unless this opposite tendency is at work
- on sloping ground, the **composition of the rock** and **soil** through which **drainage water has percolated**, or from which **rock, regolith**, or **soil particles** have been contributed, is at least as important as the actual soil parent material at any particular site.



Soil instability created by **soil frost phenomena** producing sorting, mixing, heave, and movement ***(geliturbation)***

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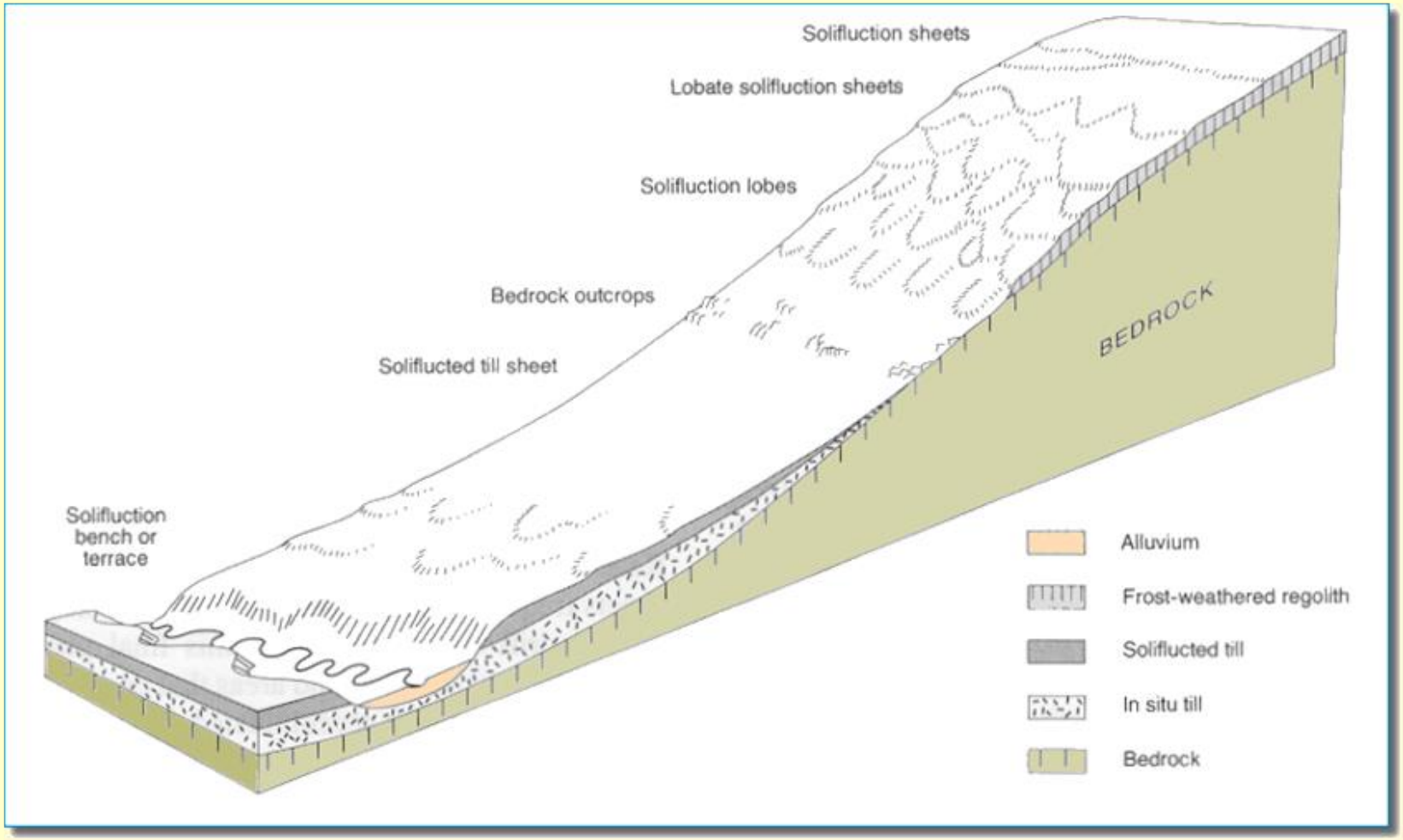
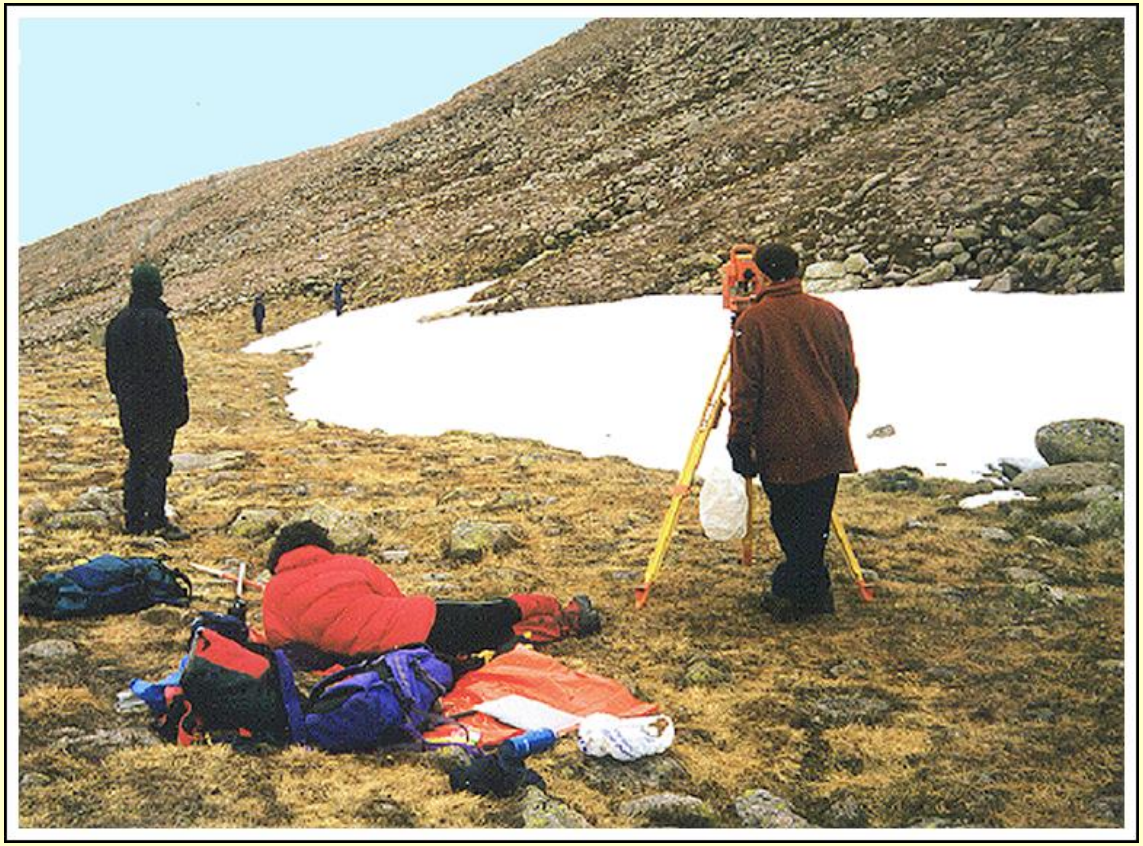
Evidence of **soil instability** in the form of **solifluction lobes** and **terraces** that create a variety of micro topographic habitats varying in exposure/shelter, drainage and potential snowlie duration.


Solifluction sheets
Lobate solifluction sheets
Solifluction lobes
Bedrock outcrops
Solifluction bench or terrace
Solifluction till sheet
BEDROCK
Alluvium
Frost-weathered regolith
Solifluction till
In situ till
Bedrock

- sites which are characterised by such enrichment are closely correlated with particular features of the microtopography of mountain areas,
- and because **moisture status** and **base status** are the most important influences affecting the floristic composition of the vegetation, these sites also correlate with particular **plant assembleges.**
- these distinctive combinations of **site microtopography**, **soil enrichment**, and **plant associations** add to the diversity of the small scale mosaic of mountain habitats.
- Traditionally these habitats have been known as:
  - **montane rills**, and **wet flushes**, where they are characterised by irrigation along discernable drainage or seepage lines,
  - and **dry flushes** where they are characterised by enrichment by solid particles, as for example in the case of screes.

- **solifluction** features such as terraces may provide combinations of these habitats,
  - with unstable but **dry flush conditions** existing on the terrace tread,
  - while the emanation of drainage water at the base of the terrace riser leads to **wet flushing**.
- however, it must be emphasised that these sites and the habitats they represent can occur at a wide variety of scales,
  - from for example a small fissure in a rock free face,
  - to sizeable spring and stream heads forming large flushed areas.
- in the Scottish Highlands and particularily in the Cairngorms the distribution of such micro habitats is further complicated by their relationships with sites of **late snowlie**, which of course are themselves sites of enrichment.



Surveying a small ablating snow patch in Coire an't Sneachda in the Cairngorms. Note its former extent betrayed by yellowed (etiolated) vegetation. Such snow patches are sites of potential nutrient enrichment

from the ecological point of view perhaps the most interesting feature of these enriched habitats is that they provide habitats for some of the rarer montane species which require exchangeable calcium levels of ***>30mg per100g oven dry soil*** *and* ***pH*** *values usually in excess of* ***5*** ***(the Calcicoles)*** *or exchangeable calcium levels in excess of* ***300mg per 100g oven dry soil*** *and a* ***pH >6.(the exacting Calcicoles)***