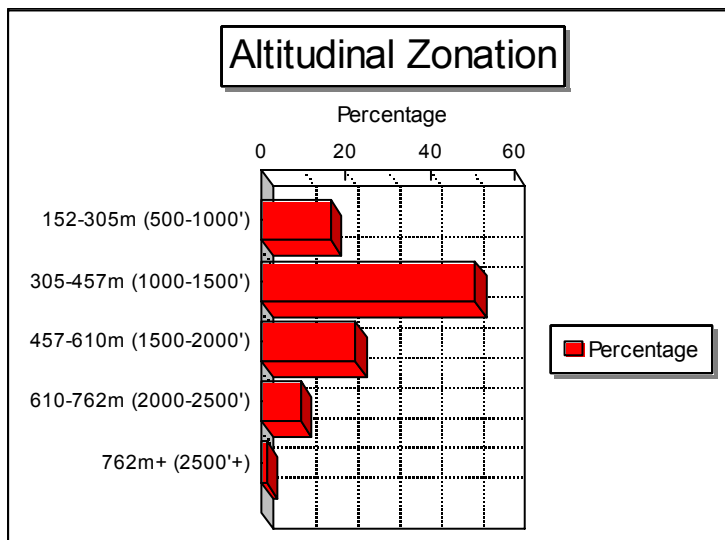


Glenlivet Website 2005 - Text

Geology and Physical Characteristics

The Geology of Glenlivet and Strathavon

The Estate lies within the 200 m - 800 m contours. The underlying geology of the area mainly consists of hard metamorphic schists and quartzites, mixed with several intrusions of coarse grained granite and bands of calcium rich limestone rocks. In places, particularly around Tomintoul, Middle Old Red Sandstone occurs.



There are a number of disused quarries on the Estate. In the past these produced 'slates' for roofing (ie. Cnoc Fergan Schist), limestone and coarse aggregate. The Ladder Hills have been mined for a number of metal ores including iron ore and manganese, which was extracted during the Eighteenth and Nineteenth Centuries at the Lecht mine. However, there are no mineral workings taking place within the estate today other than the extraction of quartzite aggregate for forest road building.

The rocks found in the Tomintoul and Glenlivet area are dominantly schists and quartzites. Schists are metamorphic rocks formed from sedimentary rocks (sandstones, shales, mudstones), which have been totally transformed by extreme heat and pressure after being buried, then exposed to the huge forces of crustal movements and the high temperatures which exist near the earth's mantle. Quartzites are formed in a similar way but have a slightly different sedimentary origin, being formed from sandstones with a high silica (quartz) content. Mixed in with the schists and quartzites are various bands of calcium rich limestone rocks as well as intrusions of coarse grained igneous granite. In places, particularly around Tomintoul, Old Red Sandstone occurs - a sedimentary rock laid down after the schists, quartzites and granite were formed.

Much of the Highlands are composed of these metamorphic schists and quartzites which geologists have broadly divided into two main groups according to their age - the Moine and the Dalradian. These overlie a much older rock called gneiss, a metamorphic rock of both igneous and sedimentary origin which was formed 2600 million years ago (mya) as part of the earth's ancient crust. Rocks from both the Moine and Dalradian series are found on the Glenlivet Estate.

The Moine Schists

The Moine schists (named after their occurrence at A'Mhoine in Sutherland), are a succession of metamorphosed sandstones of Precambrian origin, which were formed about 740 mya. Sediments washed into the sea from the ancient gneiss landscape which lay to the north of what is now Britain, were consolidated to form sandstones. These rocks were later metamorphosed to form schists with a crystalline structure which mimics the original grains of sediment. They are relatively hard rocks with a grey, buff or pink colouring, and commonly have a layered appearance like the original depositional bedding. This layering is partly the original bedding reduplicated by tight folds, and partly a banding or striping of newly-developed metamorphic minerals. The two together give a parallel structure or foliation to the rocks, which are called 'Psammitic granulites'. Geologically, they are fairly uniform and create a relatively monotonous scenery.

The Dalradian Rocks

These younger schists are much more varied and were formed from a variety of sedimentary rocks which included siliceous sandstones, shales, carbonaceous mudstones, calcareous mudstones and limestones, which are now represented by quartzites, mica-schists, black-schists, calcareous schists and marble respectively. The original Dalradian sediments (named after the first Scots kingdom of Dalradia), are thought to have been laid down during the Cambrian period (570 - 500 mya). Crustal movements had previously folded and up-lifted the Moine schists into a huge mountain range which over hundreds of millions of years had been eroded away, partly exposing the ancient gneiss. A downwarping of the crust allowed a Cambrian sea to cover much of the area which is now Britain. Sediments eroded from the old gneiss continent to the north were deposited in this marine environment of current swept shallow waters, sandy shoals, calcareous lagoons and local deeps with muddy floors. It was these sediments that were later to form the Dalradian rocks.

The Caledonian Orogeny

At the end of the Cambrian, and the start of the Ordovician (500 mya) tectonic movements caused a massive mountain building period - the Caledonian orogeny - which lasted 130 million years. It was during this period of intense tectonic activity that the sea floor mud and sand became metamorphosed into the Dalradian crystalline schists and quartzites that we see today. They and the underlying Moine rocks were raised in a mountain range of Himalayan proportions. Magma from under the crust burst through to the upper rocks and crystallized slowly to form granite. The formerly flat beds of schist were intensely contorted and heaved into huge overfolds, so much so that the junction between them became extremely distorted. It was the horizontal pressure generated from the east-south-east direction during this orogeny which is now reflected in the series of folds which give the Highlands their north-east to south-west alignment.

Old Red Sandstone

The Caledonian range on its rising was not clothed by vegetation as no plants had evolved in high enough form to invade the land at that time. During this Ordovician period, Scotland lay near the equator. The bare mountains were quickly eroded by rain and floods, depositing sands in basins, estuaries and shallow seas. These sediments, which accumulated to huge depths, eventually consolidated to form Old Red Sandstone lying on top of the older Moine and Dalradian schists.

PRESENT DAY GEOLOGY

The hills of Glenlivet and the Highlands we see today are not the direct product of the Caledonian period since the old mountain chain was eroded away and their foundations covered by later strata. Uplifted once more to a fraction of their former height, these hard metamorphic foundations have now been exposed by the removal of their sedimentary blanket, to form the Highlands. Erosion of the Caledonian mountains produced sediments now represented by the Old Red Sandstone strata. These in turn were partly covered by later sediments some of which are of marine origin, laid down when the land was depressed below sea level.

During the latter part of the Tertiary period about 26 million years ago when new crustal movements were creating the Alps, the land area of what is now the Highlands was uplifted. Previously reduced to a near sea-level plain, it rose as a solid block without folding, in a series of successional steps. The sediments, which had accumulated over the ancient schists were gradually removed by erosion, to reveal the old Caledonian mountain roots. Being harder, these rocks resisted erosion and it is these schists, quartzites and the hard igneous granite intruded into the schists during the Caledonian orogeny, that form the Grampian Highlands, of which the Cairngorms, the neighbouring Ladder and Cromdale hills and Glenlivet Estate are a part. The Cromdale hills are formed mainly of Moinian granulites, but are capped along their summits by a layer of Dalradian schist, which forms a series of bands in the Moine. The junction between the Moine and Dalradian rocks runs north-east to south-west through the estate roughly following a straight line from the Glenlivet Distillery to the Bridge of Brown. The Moine outcrops to the north-west of this line and the Dalradian to the south-east. The river Avon crosses this boundary as it makes a detour around Cnoc Fergan (GR NJ 147234).

Thus, most of the Glenlivet Estate is underlain by Dalradian rocks - dominantly quartzites, black schists (with various quartzite and limestone bands) and pelite (shale). Old Red Sandstone overlies these metamorphic rocks in the central part of the estate between Tomintoul and Tomnavoulin, extending across the Feith Musach, into the Braes of Glenlivet and up towards the Lecht almost as far as the mine.

The basin of the river Livet and its tributaries from Alanreid to the Suie and up the Blye water to Ladderfoot, is underlain by the only area of granite to be found on the Estate. The Ladder hills are entirely composed of Dalradian rocks including hard, resistant quartzites at lower levels, topped by pelite which forms the summit ridge. Small amounts of black schist and semi-pelite (with calcareous and quartzite bands) occur in the vicinity of the Lecht mine.

LANDSCAPE AND SCENERY- Glenlivet and Strathavon

Topography and Drainage

The landscape of the area is typical of the eastern Highlands with relatively smooth, gently rolling hills, which contrast markedly with the rugged, steep sided appearance of the western Highlands. While evidence of the work of ice can be identified in a number of places, the hills have not been excessively modified by glacial action, and illustrate a mixture of glacial and pre-glacial landforms which give them characteristics of their own.

The river Avon has its source high in the Cairngorms to the south west of the estate, while the river Livet originates from a number of tributaries which drain from the Ladder Hills. Both flow in a northerly direction, in alignment with the main landforms created by glacial action. The Livet joins the Avon at the northern edge of the estate before its confluence with the River Spey at Ballindalloch.

The shape of the landscape in and around Strathavon and Glenlivet has partly been determined by the areas geological past. However, the smooth gently rolling hills combined with the broad, open straths and glens, contrast markedly with the rugged, steep-sided appearance of the western Highlands, despite having a similar geological history. These differences in landform, owe their origin to various land-shaping processes which have occurred in relatively recent times - mainly processes associated with erosion and deposition by ice and water.

1. The smooth gently rolling slopes and hills

These are a relic of a warmer climate which existed before the last ice-age and have been formed principally by river and water erosion.

As Scotland was uplifted during the latter half of the Tertiary era (c. 26 mya), rivers started to cut

into the flat landscape as it emerged from the sea. Deep glens with smooth steep sides were cut into the hills and an undulating, rolling landscape was created. Softer sedimentary rocks like the Old Red Sandstone were eroded more easily than the more resistant quartzites, schists and granites which were left to form the higher ground. By the time the climate started to cool down at the beginning of the ice-age many of the sediments which had previously clothed the hill-sides had been washed away, exposing the harder rocks to the action of ice and frost.

2. Ice deepened river valleys and glens.

We are currently thought to be living in an interglacial cycle of an ice-age which began 2 million years ago. Ice-ages are characterised by several phases of cold and warm periods called Glacials and Interglacials. Many of the processes which shaped our present landscape occurred during the most recent successions of glacial or cold periods, the last of which ended approximately 10 000 years ago. It was during the successive advances of ice which have occurred during these glacial periods, that Scotland was covered in massive ice sheets up to 1000m thick, radiating huge glaciers, which eroded and modified the previously undulating topography creating much of the present scenery of the Highlands.

The shattered peaks, aretes, corries, cliffs and precipitous slopes which are so characteristic of the west Highland landscape do not occur so frequently in the eastern Highlands and are virtually absent in the Glenlivet area. It is thought that the reason for this results from the nature of the large ice-caps which covered the Cairngorms during the ice-age and the glaciers associated with them, which are thought to have been more stagnant and much less active than the faster moving valley glaciers in the west, which were fed by much higher rates of precipitation. Despite this, the eastern hills and glens were still partly modified by the ice, though not to the same extent, and as a consequence have survived with a mixture of glacial and pre-glacial landforms which give them characteristics of their own.

While a huge Cairngorm ice-cap was plucking spectacular headwalls and corries from the Cairngorm massifs during the last glaciation, large glaciers were flowing from it, down the Spey and Avon river valleys to merge with lobes of ice emerging from the Ladder Hills and Ben Rinnes. The alignment of the main landforms cut by the ice and the distribution of glacially moved boulders (erratics) indicate that the ice was moving in a north-easterly direction, often following previously eroded river channels, like that of the Avon, which were subsequently deepened and scoured out by the ice.

3. Gullies, gorges and meltwater channels

Other landforms created as the ice sheets started to retreat and melt were the gullies and gorges carved out of the rocks by glacial meltwater. This water, often flowing under enormous pressure under the ice, often exploited weaknesses in the underlying rocks and cut gashes across the main lines of the topography. Sometimes when a river valley was orientated in the same direction as the flowing ice, the meltwater cut huge gorges like the spectacular Ailnack gorge at Delnabo - one of the most impressive in Scotland. Other river channels, like the long sinuous channels through which many of the burns flow from the Ladder Hills, were incised and deepened by these fast moving torrents of water.

4. Mounds, terraces, and till deposits.

When the climate started to warm, the ice began to retreat and decay. Much of the rock debris that had been eroded and transported by the ice was dumped on top of the land surface. Rock fragments, sand and gravel were deposited underneath the glacial ice and at the ice margins, creating various hummocks, mounds and terraces. Frequently, especially beneath ice sheets, large areas of the landscape were covered by several layers of sediments called 'till'. In addition, meltwater moved and deposited 'fluvio-glacial' sediments and frequently modified and reworked the deposits left by the ice. Thus, much of Glenlivet has a layer of glacially deposited till which

underlies the soils and sits on top of the solid rocks beneath. A good exposure of till can be seen in the Carn Daimh quarry, (GR NJ 184 302) where it sits on top of the quartzite. This is an example of a till which has been deposited at the base of an ice sheet. The sediments have not been moved far because they are relatively sandy, unconsolidated, and include rock fragments which are fairly angular.

The variation of sediment sizes and the consolidated nature of certain tills, make them impermeable and drainage is impeded. In flat areas like the Feith Musach (GR NJ 195215), this poor drainage results in the development of waterlogged soils - ideal conditions for the growth of peat and raised bogs.

In Strathavon, there are numerous examples of depositional landforms, especially terraces, which were created during the retreat of the Avon glacier and have been subsequently modified by post-glacial river action. Some of these deposits were probably laid down in a meltwater delta or at the bottom of a small glacial lake at the snout of the glacier. These flat sediments have then been incised by the Avon to create flat-topped, steep sided terraces like the one on which Drummin castle is built (GR NJ 173 253).

Soils

On much of the hill ground, glacial deposits impede drainage, creating conditions that suit the development of peaty soils, with bogs and blanket peat occurring frequently at higher levels. At lower levels peaty gleys, peaty podzols and brown forest soils are more frequent and in general, the soils of the area are more fertile than those found at similar altitudes further west. Gravelly, alluvial soils can be found in the bottom of Strathavon while in the Braes of Glenlivet deep loams prevail allowing cultivation to be carried out well above 300m.

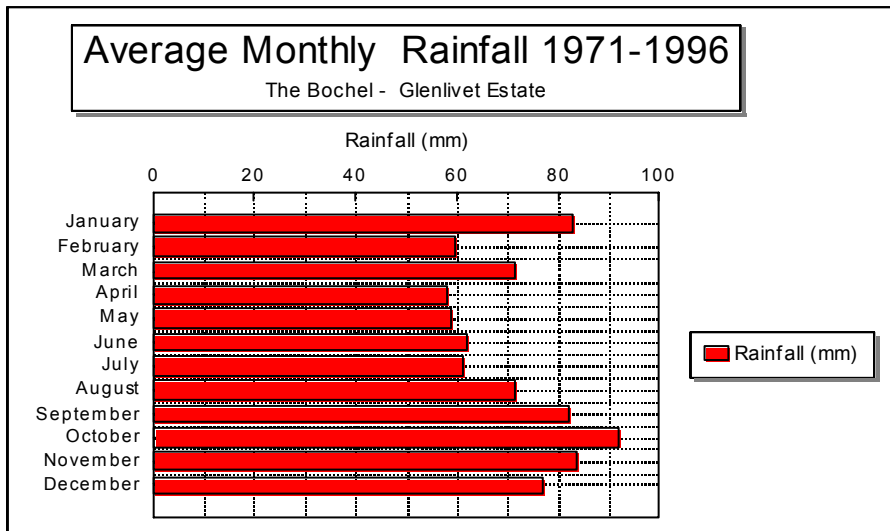
Climate

The climate of the Glenlivet area tends to be less maritime than other parts of Britain and is characterised both by very high wind exposure, particularly on the higher hills, and long, cold winters often, with hard frosts.

Several climatic categories as defined by Birse and Dry (1970) and Birse and Robertson (1970) are represented in the area and these include:

- Cool rather wet lowland, foothill and upland
- Cold rather wet foothill and upland
- Cold wet upland
- Very cold wet upland and mountain
- Moderately exposed with rather severe winters
- Exposed with rather severe winters
- Very exposed with very severe winters
- Extremely exposed with very severe winters

The growing season is therefore short and snow on the hills can often last late into the spring. The high Cairngorms to the south west however, intercept much of the rain carried on the prevailing westerlies, and the area is one of the drier parts of Scotland having a rainfall in the region of 800 - 1000 mm per year (see table 1).



Vegetation

None of the estate is below 200m and there are expansive areas over 500m. Altitude and exposure limit plant growth on the high ground but in general the countryside consists of a varied mixture of different habitats including deciduous woodlands, improved and unimproved grassland and coniferous plantations in the lower areas, through to extensive heather moorlands, raised peatland, bogs and montane heath on the higher hills, which extend above 800m.

The appearance of the landscape has been greatly modified by management, but stands of semi-natural woodland have survived forest clearance, and give an indication of how the landscape might have looked before human settlement, when a mixed deciduous woodland would have covered much of the area. Pine and birch would once have been more dominant on the higher slopes, extending above 600 m, and while areas of birch still remain, the only remnants of the once extensive Caledonian pines are the scattered stumps which can be found in certain areas buried and preserved in peat.

SEMI-NATURAL WOODLANDS ON GLENLIVET ESTATE

The Value of Semi-Natural Woodlands for Nature Conservation

Prior to man's influence, woodlands were the most extensive natural habitat in Britain and the great majority of our wildlife is adapted to and relies on woodland conditions for germination and growth, feeding, breeding, cover or shelter. Native woodlands were extremely complex in structure and composition with a wide variety of tree species in the canopy and understorey, a shrub layer, a rich ground and litter layer, dead and dying trees, glades etc. These would vary with the ground conditions and other environmental factors, each component providing a series of niches for a diverse community of flowering plants, mosses, fungi, ferns, birds, mammals, etc.

It is doubtful whether any woodlands in Britain are now totally "natural", all having been modified to some degree by man. However, semi-natural woods have, in general, been modified to a lesser degree and most closely resemble the native woodland cover of Britain. Semi-natural woods are those which are composed predominantly of species native to the site and which have become established by natural processes, their distribution reflecting the variation in conditions within the site. The other main category of woodlands is plantations. These are generally much

more influenced by man and more intensively managed. They are often composed of fewer tree species (including non-native species), are even-aged and structurally simple, and involve modification of natural ground conditions. Many woodland species are also absent since they are slow at colonising new sites. The overall woodland community is therefore usually much more limited and dominated by a few adaptable or mobile species. Another important difference is that plantation communities are recreatable whilst those of semi-natural woods, once lost, cannot be recreated except in the very long term.

In addition to their origin, two other factors are important in determining the relative value of a wood for nature conservation - the history of woodland cover and its management.

All other factors being equal, the longer a site has been under continuous woodland cover, the richer the wildlife community which occurs there. This applies to both semi-natural and plantation woods and has led NCC to prepare its Ancient Woodland Inventories such as the one for Moray. In this, woodland sites are classified as ancient (i.e. shown on maps from c1770, c1850 and c1880), long-established (i.e. shown on maps from c1850 and c1880) or other (shown on maps from c1880 but not c1850). The identification of ancient and long-established semi-natural woods (and some long-established plantations of native species on former woodland sites) has proved useful in highlighting those sites which have greatest potential for nature conservation.

Although the canopy composition of a wood and the history of woodland cover can be good indicators of a site's value, the impact of management (particularly grazing by livestock) can be decisive. Prolonged heavy grazing can prevent regeneration, thereby opening up the wood and simplifying its structure, and drastically modify the ground flora. If practised over a long period it will inevitably destroy a woodland and create a relatively species-poor pasture dominated by grasses. The value of many semi-natural woods often depends on how far along this process of degradation it has reached.

The Extent and Composition of Semi-Natural Woodlands on Glenlivet Estate

Woodlands on Glenlivet Estate probably reached their maximum post glacial extent some 7000 years ago when all but the high tops of the Ladder and Cromdale Hills were wooded. This native woodland cover has been progressively depleted by clearance, grazing and possibly climatic change. The accompanying map shows the approximate extent of semi-natural woodland remaining on the Estate. This is based on a Natural Habitat Survey undertaken in 1983/84 by Grampian Regional Council. Some 550 ha are shown, the great majority on the steeper or less well drained ground along the main river valleys. (It should also be pointed out that many smaller groups of trees or linear strips along riverbanks or field boundaries have not been identified but nevertheless form an important component of the woodlands on the Estate).

The majority of semi-natural woods on the Estate are now largely composed of birch with frequent rowan. These are commonly associated with the humus iron podsols of the valley slopes. Where only lightly grazed, the ground flora of these woods is dominated by blaeberry and cowberry with heather, bush vetch, wood anemone, violets, chickweed wintergreen, hard fern, oak fern, etc and there is often a good shrub layer of juniper (e.g. Bochel, Craggan, Cnoc Fergan). In some areas birch and eared willow occur on gleyed peats with a ground layer of *Molinia* grass, heather, bog myrtle etc (e.g. Bochel, Ballantruan).

Birch woodland also occurs on well drained brown forest soils and fluvio-glacial deposits (e.g. Creag nan Gamhainn, Doune, Strathavon Lodge). These are less extensive and are often indicated by the presence of hazel and a ground vegetation of soft grasses, *Dryopteris* ferns, bracken, wood sorrel, greater stitchwort, primrose etc. On the limestone of Creag nan Gamhainn the flora is very rich indeed with several local and national rarities.

The other common tree species is alder which is dominant on the alluvial soils and gravels of the river flood plains and the gleyed soils below springlines on the valley sides. Bird cherry is also

abundant in these areas and birch remains a frequent component. The ungrazed ground vegetation consists of extensive dog's mercury and greater woodrush with meadowsweet, angelica, nipplewort, bugle, golden saxifrage, wood avens, yellow pimpernel, etc.

The only other widespread native tree is aspen which occurs as distinct clones amongst many birchwoods. Ash, wych elm, gean and goat willow are confined to a few flushed brown forest soils in the lower reaches of the Avon and Livet, often on steep burn-sides. Oak is also scarce (the nearest large stand being at Shenvall opposite Doune) but may have been more frequent in the past amongst sheltered birch/hazel woods. Whilst oak may have been selectively felled in the past, it is also possible that the local climate may have limited its abundance in these upper glens.

The almost complete absence of Scots pine (outside plantations) is striking since it is likely that large areas of peaty pod-sols above the main valleys supported native pine woodland in the past. Such woodland, comprising pine, birch and juniper, still exists at nearby Abernethy. Scots pine was probably also a component of acid birch woodland on the valley sides but the nearest native remnant is in Upper Glen Avon. Self sown Scots pine does exist on several moorland areas on Glenlivet and on some river shingles but these are all thought to derive from seed from plantations.

The NE of Scotland is noteworthy for the abundance of juniper and Glenlivet is no exception. As well as being a frequent component of most birchwoods it occurs in many other semi-natural habitats, often as a relict of past woodland cover. Juniper scrub is also an important habitat in its own right and was probably characteristic of glades in former native pine woodland and the exposed upper margins of woodland cover. Examples of this submontane juniper scrub are now scarce in Britain but several remain on Glenlivet Estate (e.g. Feith Musach, Alltach Beag, Well of Lecht etc.)

Other native shrubs are scarce on Glenlivet Estate. Hawthorn, sloe and elder occur in a few lowground sites (often near farms) and blackcurrant is found in a few alderwoods. Dog rose, broom and whins are however common, especially in disturbed areas.

There are very few policy or ornamental plantations on the Estate but some larch, ornamental conifers, beech, lime, sweet chestnut etc have been planted near large houses and villages, e.g. Kynadrochit, Drumin, Auchbreck and Bridgend of Glenlivet. Some native species such as gean and wych elm have also been planted as have hawthorn hedges at Nevie. The most widespread introduced broadleaf is sycamore which has been planted around many farms for shelter. Sycamore has spread to several riverside woods but is not common except in a few woods near the foot of the Livet where there is abundant regeneration. Other introduced plants which are particularly invasive in some Scottish woods are very localised on the Estate (e.g. rhododendron, snowberry, leopardsbane).