5. Discussion

5.1 'Bog woodland' - the problem of definition

In many parts of Europe, especially Fenno-Scandia, scattered trees can occur across the surface of a bog in a relatively stable ecological relationship as open woodland without the loss of bog species (Ruuhijärvi 1983, Sjörs 1983). This is a much rarer condition than the progressive invasion of bog by trees, through natural colonisation or afforestation following changes in the drainage pattern, which leads to the loss of the bog community. The structure and function of this habitat type is finely balanced between tree growth and bog development. Tree growth, however, is always slow (or the bog would become woodland); the trees are widely spaced (because much of the surface area is too wet for them to establish) and dead trees may be common even among the fairly small individuals (because their weight depresses the peat locally leading to waterlogging and death).

Until recently, the habitat has been overlooked in most ecological accounts of British vegetation (JNCC 1999a). During the 1990s however, awareness of the possible existence of analogues to continental 'bog woodland' has been raised. In particular, the review of MacKenzie & Worral (1995) was especially influential in drawing the attention of the conservation community to the possible range of the habitat in Scotland. Unfortunately, it also inadvertently helped sow seeds of semantic confusion in the subsequent conservation literature and survey reporting. This is because MacKenzie and Worral chose to define 'bog woodland' literally, as 'ombrotrophic wooded bogs', restricting the range of wooded mire communities falling within the compass of the term to *ombrotrophic* systems (dominated typically by M17-20 communities or variants thereof).

However, careful reading of the current European legislative conception of 'Bog woodland' indicates that the term is intended to be applied to a much wider spread of mire types than simply ombrotrophic ones. Instead, it is clear that the spirit of the European definition of the habitat type covers just about every wooded wetland community apart from fen carr and riverine woodland. As well as ombrotrophic bogs, it also embraces weakly minerotrophic communities such as poor-fens, as well as spruce *swamps* (European Commission 1996, 114). The classificatory waters are muddied still further by the fact that it would clearly be possible - although not helpful - to stretch the current lax EU definition of 'bog woodland' to include invasive colonisation of drained and desiccating bogs by trees - a community currently regarded as undesirable under current SNH mire management guidelines (SNH 2001).

It is clear from this that a much more rigorous ecological definition of the range of wooded mires is required; one that is easily interpretable within a British context and which emphasises the stability of the woodland-bog vegetation dynamic. The root of the current problem of definition within the UK remains with the use of the term *bog* woodland, which, strictly speaking, MacKenzie & Worral are correct to interpret as restricting the woodland type to purely rain-fed systems. However, extensive bog systems are rarely

completely ombrotrophic. Blanket and intermediate mires often display a gradation of trophic status from central, true ombrotrophic cores, through weakly irrigated peripheral areas of peat. Theoretically (and in actuality) the latter areas may carry woodland growing in conjunction with poor-fen communities over deep peat which are not truly ombrotrophic, but which are also not richly minerotrophic. As long as the term *bog* woodland is understood to encompass such a mosaic of predominantly acid mire types, it is probably workable. The selection of sites chosen to represent the habitat has effectively recognised this, and used a 'common sense' approach, even though it has not been expressed formally. This, a number of bog woodland cSACs include areas of poor fen in addition to the 'core' bog area.

At the moment, however, the ambiguity means it is still possible for different workers to take different views, leading to several differing interpretations of the habitat definition. So, in contrast to MacKenzie & Worral, recent usage of the term includes that by McHaffie *et al* (2000) who employ it in a restrictive sense to mean specifically, 'Predominantly woodland vegetation with tall, dense tree cover on deep peat…with most bog vegetation in the ground flora replaced by woodland bryophytes and shrubs.' - a radically different meaning to previous usage.

5.2 Interpretation of 'bog woodland' in the present study

In view of the potential confusion inherent in the phrase 'bog woodland', therefore, it would probably be far better to get rid of the term altogether and replace it with something entirely new However, it has become so entrenched in the survey and legislative literature that it is impossible to ignore at the present time. For the purposes of the present report, therefore, the author decided on a pragmatic approach when assessing whether true 'bog woodland' was present on a site or not. It was assumed the term is intended to include a much wider range of wooded acid mire types than the purely ombrotrophic systems favoured by MacKenzie & Worral, or the narrow definition recently proposed by McHaffie (2000). Instead, the broad span of the European definition was more or less followed, taking into account systems with mosaics of trophic status, but nevertheless ensuring the systems are predominantly acid in nature. Instead, when evaluating the communities the emphasis remained on the following key attributes:

- An assessment of the relative ecological *stability* of the open woodland-bog vegetation combination.

- The characteristic patterns of growth and survival of the tree species on the bog surface.

- The sub-surface morphology of the peatland ecosystem - whether the trees are actually rooted in deep peats.

The emphasis on the perceived long-term *stability* of the wood-acid mire system ensures that invasive scrub on desiccating peatland is effectively excluded from this definition.

5.3 Comparative overview of the seven sites

The survey established beyond doubt that tree growth at every site was established on genuine mire peat (sometimes of considerable depth). In other words, the communities did not represent tree growth on mineral substrates masked by superficial cover fresh of *Sphagnum*, or trees restricted to peripheral mineral ground transitions to mires. However, under the terms of the 'bog woodland' definition outlined earlier, it is the opinion of the author that the small site at Mar Lodge failed to meet the criteria for the habitat on the grounds that the site probably represents invasive colonisation of disturbed and desiccating peats by trees, rather than a stable bog-wood system. All the other sites, however, were felt to fall within the compass of the definition.

One of the most striking aspects which emerged from the study was the stratigraphical variety exhibited by the sites. The range of peat depths, topographical situations and site histories showed considerable differences from place to place. For example, extensive areas of Monadh Mor comprised peat of only ca. 1-2 m depth, whereas Eilean Subhainn contained some areas of tree-covered peatland which reached in excess of 4.5 m. However, a common feature of many of the sites seemed to be disturbance to the upper peat stratigraphy. It is possible that many of the bog woodlands are therefore comparatively recent in origin (i.e. <150 years old). The one exception may be the Loch Maree islands where no truncation to the peat stratigraphy was detectable and where charcoal was not recorded abundantly. Although the current data do not conclusively prove the longevity of stunted bog pine communities on the islands' mires, neither do they contradict the notion that they might be of considerable antiquity. Many other sites appeared to show evidence for extensive truncation of upper peats, most notably at Inshriach, Monadh Mor, Pitmaduthy and some parts of Rothiemurchus. Monadh Mor, Pitmaduthy and Inshriach appear to exhibit the most extensive and systematic disturbance to the peat stratigraphy, probably from ancient turbary. Monadh Mor seems to exhibit the most extreme form of this, retaining only small central areas of deeper organic stratigraphy, surrounded by large areas of shallow (1 m deep or less) 'fresh' very wet *Sphagnum* and *Polytrichum* peats. The inference that may be drawn is that the pine bog woodland communities at several sites, or parts of sites, are relatively recent in origin and may represent fresh colonisation of the site by the habitat (or a recolonisation after precursor communities had been removed by drainage and peat cutting). More detailed stratigraphical work combined with studies of the historical ecology are needed, however, before such conjecture can be translated into fact.

Evidence for peat cutting was absent at Lòn Lèanachain, but instead there is circumstantial evidence that a combination of past grazing pressures and burning may have discouraged birch growth in the peripheral areas of the bog. The Rothiemurchus sites, similarly, may represent areas which are returning to some kind of equilibrium after centuries of intense grazing pressure and burning (as well as some turbary), following changes in management practice.

5.4 Density and age structure of pine woodland

The density and age structure of the 'woodland' varied considerably across the suite of sites. McHaffie *et al* (2000) proposed a tripartite division to describe the differing densities of pine populations on sites in Abernethy.

These were:

(1) 'Woodland bog' - *predominantly bog vegetation with abundant pine seedlings due to the heavy seed rain from surrounding woodland. There is high seedling mortality and the few trees that survive are very stunted, heavily diseased and produce rather few seeds.*

(2) 'Wooded bog' - *predominantly bog vegetation with scattered mature trees of moderate height but leaving an open canopy. The trees are fertile and often form uneven aged stands through regeneration.*

(3) 'Bog woodland' - *predominantly woodland vegetation with tall, dense tree cover on deep peat. The trees are well grown with a dense canopy. A few remnants to bog vegetation remain in the ground flora, though most has been replaced by woodland, bryophytes and shrubs.*

The present author feels that this tripartite terminology is potentially confusing. For example, category 3 sounds like it might arguably even fail to meet the EU definition of 'bog wooldand' due to lack of mire species!
However, if used as a rough, superficial way of differentiating between differing tree densities on bog woodland sights, the above categories allow a rapid visual assessment to be made of sites, based on tree density. This does not necessarily allow conclusions to be drawn as to forcing mechanisms behing tree distribution however.

Using this classification, the pine populations existing at Inshriach sites M1, M2, M3, M4, and parts of Monadh Mor and Pitmaduthy are probably encompassed by category (1). Inshriach site M5, parts of Monadh Mor and Pitmaduthy and Rothiemurchus approximate to Category (2). The Loch Maree sites are difficult to place in this scheme because of their uniqueness (stunted, but apparently largely healthy pine communities, some of considerable age) and might be said to fit somewhere between Categories (1) and (2). Lòn Lèanachain, being a birchwood, is not necessarily encompassed by the McHaffie criteria but the tree distribution would tend to fit with Category (2) in terms of density and age structure. Mar Lodge does not easily fit in any of the categories, but probably most closely approximates to (3) under this scheme.

5.5 Peat depths, hydrology and nutrient enrichment
While peat depth appears to be superficially related to the size and success of colonising birch at Lòn Lèanachain (p. 20, plates 1,2), it is clear from Eileann Subhainn (Loch Maree Islands) that surface drainage is possibly a more important controlling factor in determining size, and density of tree growth in the long term (p. 42, plate 10). Such factors may be less important for short-lived individual trees transiently existing on very wet substrates, where the sheer 'firepower' of a surrounding seed source ensures continual recruitment (MacHaffie Category 1). Monadh Mor and the Inshriach sites probably benefit

from such a phenomenon. However, another possible controlling influence on colonisation of very wet peats might be enrichment by fertiliser from adjacent forestry operation. Some of the 'basin sites at Inshriach (*e.g.* M3, M4) for example, are strongly reminiscent of some small wooded English bogs which are also surrounded by Forestry (*e.g.* Abbots Moss, Cheshire) but where the natural status is debatable because these sites have become N and K enriched (Bryan Wheeler, *pers com*).

5.6 Further research

The current study is, as far as is known, the first systematic attempt to describe the peat stratigraphy of bog woodland systems in the UK. Although a valid indicator of palaeoenvironmental history, the present rapid assessment is relatively crude. It could, however, provide a suitable context for a more detailed ^{14}C dated study of pollen and plant macrofossils from several sites More detailed quantitative macrofossil study of cores from the bog woodland and main mire expanse area would help to elucidate much more clearly the history of past bog woodland on many of the sites, and the effects on vegetation of ancient landuse (such as burning frequency). Future management strategies would also benefit from the reconstruction of the 'natural' bog vegetation of the recent past. A precedent for this approach is been undertaken by the Countryside Council for Wales at Borth Bog where macrofossil analysis is being used to reconstruct past mire vegetation to help inform best management practice (Peter Jones, *pers comm*). Using Lòn Lèanachain as a specific example, if such an approach was complemented by pollen analysis, it would supplement the site-specific information from the macrofossils, generating a picture of vegetation dynamics and land-use changes in the surrounding catchment, including the original composition of the woodland fringe. Again, there is a precedent for such an approach, in the form of Scottish Natural Heritage's palynological initiatives in Glen Affric, Mull and Greenhead Moss, Lanarkshire, and the Carrifran reafforestation project in the Borders (Tipping, 1998; Long & Tipping 1998;Tipping *et al*, 2000). Every site would also benefit from studies researching their historical ecology. Such an approach can often reveal much about the past landuse history of habitats (Sheail, 1980). In the case of Monadh Mor, Pitmaduthy, and the Inshriach sites, it will probably be crucial if we hope to understand how the modern systems have become established.

Finally, close examination of recent forestry practices surrounding those sites especially affected by it (Inshriach, Lòn Lèanachain, Monadh Mor) would be useful, especially with reference to the possibility of 'fertiliser creep' and the enrichment of surface peats by N and K.

6. Glossary of terms

Basin mire Mire developed in enclosed waterlogged depressions which have become colonised by peat forming vegetation. Most often found in areas of glacial deposition where local irregularities of relief such as kames and kettle holes provide the necessary geomorphological environment of hollows with enclosed drainage. Usually characterized by relatively small surface area (*ie* <50 ha) compared to depth (often >5m).

Biostratigraphy Stratigraphy based on changes in biological assemblages in the sediment (*eg* pollen zones).

Blanket mire Peat developed directly over mineral ground up to a considerable angle of slope (10-25^0) normally in an upland environment.

Bog General term for ombrotrophic mires.

Bog burst Catastrophic failure of structural and hydrological integrity of a peat bog. The cause remains unknown but is always associated with a rapid increase in amount of water entering the system (usually caused by prolonged heavy rain). Bog bursts are rare events but may have been commoner before modern agriculture improved drainage of mire systems.

BP Before present. In terms of radiocarbon dates present is defined as 1950 AD.

Bryophyte Member of the major group of the plant kingdom comprising the mosses and liverworts.

Fen General term for minerotrophic mires.

Gyttja Fine detrital mud, usually deposited in open freshwater conditions. Synonym- *Nekron Mud*.

Holocene The present interglacial stage, dating from *c*13 000 years BP to the present.

Humification Degree of decomposition (of peat).

Hydrosere A plant succession commencing in waterlogged sites.

Intermediate mire Mire characterised by a stratigraphic profile indicating the overgrowth of a peat reservoir to cover low amplitude water partings causing coalescence with other peat reservoirs in adjacent basins. Intermediate because they form a type of mire morphology transitional between true raised mires and blanket mires. Synonym: *Ridge-raised mire*.

Macrofossil Usually taken to mean plant macrofossil.
A term which covers everything that cannot be considered a microfossil. It effectively includes all plant remains which can be recognized by the naked eye or with the aid of a low power microscope. The semi-decomposed plant remains are not true fossils, in the conventional geological sense of the term (*ie* having petrified tissue), but are sub-fossils. Cell contents are generally replaced by water in the peat sub-fossil material.

Minerotrophic Used to describe a mire whose surface receives water from outside that mire's own limits.

Mire Peat-producing ecosystem which develops in sites of abundant water supply.

Mire macrotope Mire complex which has been formed by the fusion of isolated mire mesotopes.

Mire mesotope Mire system developed from one original centre of peat formation.

Monocotyledon Abbr. *monocot.* Group of flowering plants possessing only one cotyledon. In the context of macrofossil assemblages, often used as a convenient shorthand to encompass undifferentiated remains of grasses, sedges and rushes.

Ombrotrophic Literally, "fed by rain". Used to describe a mire which receives water only directly from the atmosphere in the form of precipitation.

Ontogeny Biological or ecological development through time.

Palaeoecology The study of past interactions between plant and animal communities and their environment.

Palaeoenvironment An ancient environment.

Palynology The science and practice of pollen analysis.

Paludification Initiation of mire formation over mineral ground by the lateral expansion of peat.

Peat Partly-decomposed organic material formed in areas of permanent waterlogging.

Phase-shift Change in macrofossil assemblage indicating a change in surface hydrological conditions (ie from a wetter to a drier situation or vice versa).

Pollen zone A body of sediment with a consistent and homogeneous fossil pollen and spore content which differs in type and frequency from that of adjacent bodies of sediment. See *Chronozone.*

Post-Glacial Used to denote the temperate period since the end of the Devensian at *c*10 000 radiocarbon years BP.

Radiocarbon Dating A method of dating ancient organic material. The technique involves the measurement of amounts of radiocarbon (which is subject to decay after death) remaining in organic matter. *Calibrated* radiocarbon dates have been converted to calendar years using and are distinguised by the use of the suffix "cal BC/AD".

Raised mire Ombrotrophic mire characterised by a very low amplitude convex profile and usually occupying topographical situations such as level floodplains of river systems and alluvual deposits of estuaries. The ontogeny

of raised mires usually indicates that ombrotrophic plant communities have developed over minerotrophic and/or aquatic ones as upward growth of peat has insulated the surface from groundwater influence.

Ridge-raised mire Synonym for intermediate mire.

Sere Plant succession.

Skirtland Dark-stained soil derived from decomposed peat. Skirtland represents the edges of former mossland which have retrenched due to disturbance (usually by agriculture).

Sphagnum "Bog moss". Genus of mosses often dominant in ombrotrophic mires which are characterised by their water retentive hyaline cells.

Top-moss relict, untruncated peat stratigraphy

Turbary A specific area of peatland used for systematic peat cutting

Valley Mire Mire occurring in small, shallow valleys or channels which are not enclosed so that movement of water along the long axis is possible even with only a slight gradient. Typical of wet, elongated depressions in acidic heathland areas of lowlands.

Wetland A term which has still to achieve a commonly accepted meaning in common usage. Its ecological meaning remains vague but is usually defined as an area characterised by a water table which, for a significant part of the year, lies close to the substrate in which vegetation is rooted.

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