WINDFARM IMPACTS ON BLANKET PEAT HABITATS IN SCOTLAND

Tom Dargie

Boreas Ecology
Loch Fleet View, Skelbo Street, Dornoch, Highland IV25 3QQ

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INTRODUCTION

Much blanket peat is developed over relatively smooth ground in very windy environments, and thus offers considerable potential for wind energy conversion. This paper represents a review of likely windfarm impacts on blanket peat habitat. The review is speculative for two main reasons. First, the number and location of windfarms is not known. Scotland in May 2004 had 17 grid-connected windfarms, with a further two under construction and a large but uncertain number of applications submitted for planning permission or likely to go to planning in the next year or two. Second, given the long duration of upland habitat successions (Gilbert & Anderson, 1998; Marrs, 2003), windfarm longevity (20 - 25 years) and the effects of decommissioning, a full appraisal of windfarm impacts will probably not be possible for at least three decades.

The information presented is based on recent environmental statements submitted for planning permission. The author has contributed to 13 EIAs covering windfarms at least partly on blanket peat, and has personal experience as project ecologist (ecological clerk-of-works) for construction, ground restoration and monitoring at Novar Windfarm, Ross-shire (the first major windfarm in Scotland, built 1996-97, operating since October 1997) and at Causeymire Windfarm, Caithness (currently under construction).

BLANKET BOG HABITAT

Blanket peat forms a soggy, tweedy-coloured mantle over large areas of upland Britain. Its extent in Scotland is estimated at 10,680 km^2 by Lindsay & Immirzi (1996) and 10,560 km^2 for peat >1 m deep (Coupar, Immirzi & Reid, 1997). This represents 13% of Scotland's land area, 74% of UK blanket peat area, and perhaps 10% of the global resource for this habitat (Lindsay *et al.,* 1988). It is characteristic of wet and cool oceanic climates, forming peat usually between 0.5 and 5 m thick, with 2 m perhaps being close to a Scottish average. In Scotland its lower levels start at around 300 m in the Southern Uplands but falls to almost sea-level in the Western Isles, northern Sutherland, Caithness, Orkney and Shetland as a result of steepening temperature lapse rates at high latitude. Likewise, it changes to sub-alpine dwarf-shrub heath above about 600 m in the central Highlands, with the transition dropping to about 300 m in Lewis, Sutherland and Caithness.

The nature conservation value of the best blanket bog is outstanding (Stroud *et al*., 1987; Lindsay *et al*. 1988., Lindsay, 1995). The rain-fed (ombrotrophic) mires support major breeding bird populations on ground dominated by bog mosses *Sphagnum* spp., dwarf shrubs, sedges and occasionally lichens, with extensive pool systems forming patterned ground. The habitat spans two Habitats Directive Annex 1 types (Blanket bogs; Depressions on peat substrates of the *Rhynchosporion*), with 'active' blanket bog listed as a priority habitat. Active is defined as 'still supporting a significant area of vegetation that is normally peat forming' (European Commission, 1996). Good blanket bog in Britain is found as mosaics of several mire National Vegetation Classification (NVC) types (M1, M2, M3, M17, M18, M19, M20, and M21). The Flow Country of Caithness and Sutherland is the largest single world expanse (401,000 ha) of this habitat (Lindsay *et al*., 1988).

The Scottish blanket peat resource is also an important carbon sink, as well as being an archive of past environments and biodiversity (Barber, 1993). A back-of-an envelope calculation suggests that the above Scottish area and average thickness represents a store of 960 million tonnes of carbon, assuming a bulk density for undrained wet blanket peat of 1 t / m^3, a water content of 90% for undrained peat, loss on ignition of oven-dried peat at 95%, and undecomposed plant material representing mainly cellulose with 44.4% C by weight. Most of this store has formed over the last 5-6,000 years. The median rate of peat growth on blanket peat in Britain from a sample of 62 dated cores is 0.4 mm / yr^{-1} (Tallis, 1995), probably equivalent to about 20 gC / m^{-2} / yr^{-1}. We know little in Britain about trends in rate of peat growth but work in Western Siberia (Glebov *et al*.) suggests that peat accumulation has decreased over time (9,500 to present) from 1.9 to 0.3 mm / yr^{-1}.

Not all blanket bog is pristine. Degraded conditions due to natural erosion, drainage, excessive grazing, burning and acid deposition are usually shown by significant extents of the NVC types H9, H12, M15, M16, M25 and U6 (JNCC, 2004) and, arguably, M20. Commercial and domestic peat extraction, forestry, improvement for pasture, erosion (hagging and gully erosion, bog slides or bursts), drainage, atmospheric pollution, grazing, burning and vehicle use are all noted as important at varying scales in Scotland (Coupar, Immirzi & Reid, 1997), although quantification is difficult and is being addressed in a Blanket Bog Inventory of Scotland by Scottish Natural Heritage (SNH). Windfarms and associated infrastructure are listed as a threat to blanket bog in the UK HAP for this habitat (UK Biodiversity Group, 1999). How serious is this threat, especially in comparison to other pressures upon this habitat? This question is addressed below and is restricted to the habitat, excluding bird issues.

WINDFARMS AND BLANKET BOG IN SCOTLAND: A SAMPLE

Sites underpinning this paper are located in Figure 1. Habitat survey (a combination of NVC and Phase 1 methods, with emphasis on the former) has covered almost 130 square kilometres, with blanket bog forming 33% of this extent. Several features of windfarm proposals affecting blanket peat are shown by this site mix, which is probably fairly representative of most applications covering this habitat:

- There is much variability in size (360 to 3670 ha), as measured either by habitat survey extent which usually extends 500 m beyond a turbine envelope, or in terms of the area of blanket peat involved (10 - 898 ha).
- In future extensions could be proposed to an existing site, e.g. an application is pending for Novar Windfarm.
- Planning permission is not a formality, with Helmsdale (an aggregate of three near-contiguous proposals) refused approval after public enquiry in 1997.
- There might be blanket bog gains, as well as habitat loss. The largest sites are associated with commercial forestry and would mainly involve substantial clear-felling of lodgepole pine and sitka spruce planted on former deep peat, offering opportunities for modest areas of blanket bog improvement (Aultmore, Clashindarroch) and perhaps some re-establishment after felling young plantations at the pre-thicket stage (Cruach Mhor, Ewe Hill).

- Site choice has generally avoided designated ground, with only the Clashindarroch proposal affecting a Site of Special Scientific Interest (SSSI), by upgrading an existing stone road through an adjacent SSSI for access to the windfarm site.
- The quality of blanket bog habitat that could be affected is varied, but much is already fragmented by forestry, lacks pool systems, is dominated by mainly dry NVC types and has been highly altered by many decades of chronic sheep grazing or extensive drainage. Old peat cuttings are also present. Good (near-SSSI) quality habitat with wet peat and good pool systems is only present at Causeymire and Ben Aketil.

THE EIA PROCESS AND THE ACCURACY OF IMPACT PREDICTION

Assessing windfarm impacts is obviously addressed in an environmental statement (ES) accompanying each of the windfarms covered in Figure 1. The author uses the draft Institute of Ecology and Environmental Management (IEEM) methodology, modified slightly to fit a Scottish context. However, predictions (including mitigation) in these documents do not necessarily represent an accurate representation of a development that is later given planning approval. Responses from statutory and non-statutory agencies, plus the public (including a vociferous and effective anti-windfarm lobby), can produce important changes to site layout. A proportion of proposed turbines can be removed and others changed in position. Borrow pits for stone, access and site roads can change substantially both in design and position. Finally, planning conditions may include a Section 75 Management Agreement, which has to be agreed in detail with bodies such as SNH, Scottish Environment Protection Agency (SEPA) and the Royal Society for the Protection of Birds (RSPB) before construction can begin. The detail can differ from that given in the initial ES as mitigation. These differences from the ES are the result of a broader EIA process that then often extends into the construction and operational phases, and will possibly include the decommissioning stage too. The construction of windfarms at Novar and Causeymire has involved close liaison with SNH and RSPB. Bird and restored ground monitoring at Novar is agreed annually via formal environmental group meetings (developer, project ecologists, SNH, RSPB and The Highland Council), which consider detailed progress reports. An equivalent environmental group will operate at Causeymire once the site is operational.

IMPACTS FROM BORROW PITS, ROADS AND CONSTRUCTION AREAS

Roads are usually the first piece of windfarm infrastructure to be constructed, together with a temporary construction area (TCA). The size of the latter is usually 1 - 3 ha, formed over stone laid over geotextile on a near-level surface. Stone for roads and a TCA is won either from borrow pits (1 ha approx. at Novar, sited on wet heath and restored after use by top dressing with peat and re-seeding with a grass - heather mix) or from existing nearby quarry waste (Caithness Flag) at Causeymire.

Road location is very important and ecological feedback has been used in author contributions to recent EIAs, identifying suitable ground, minimising crossings of watercourses and avoiding wet and deep peat (peat coring along proposed road routes is undertaken in most studies). Overall, roads form the largest impact on blanket bog in road design is also important and substantial improvements to existing hill road types were

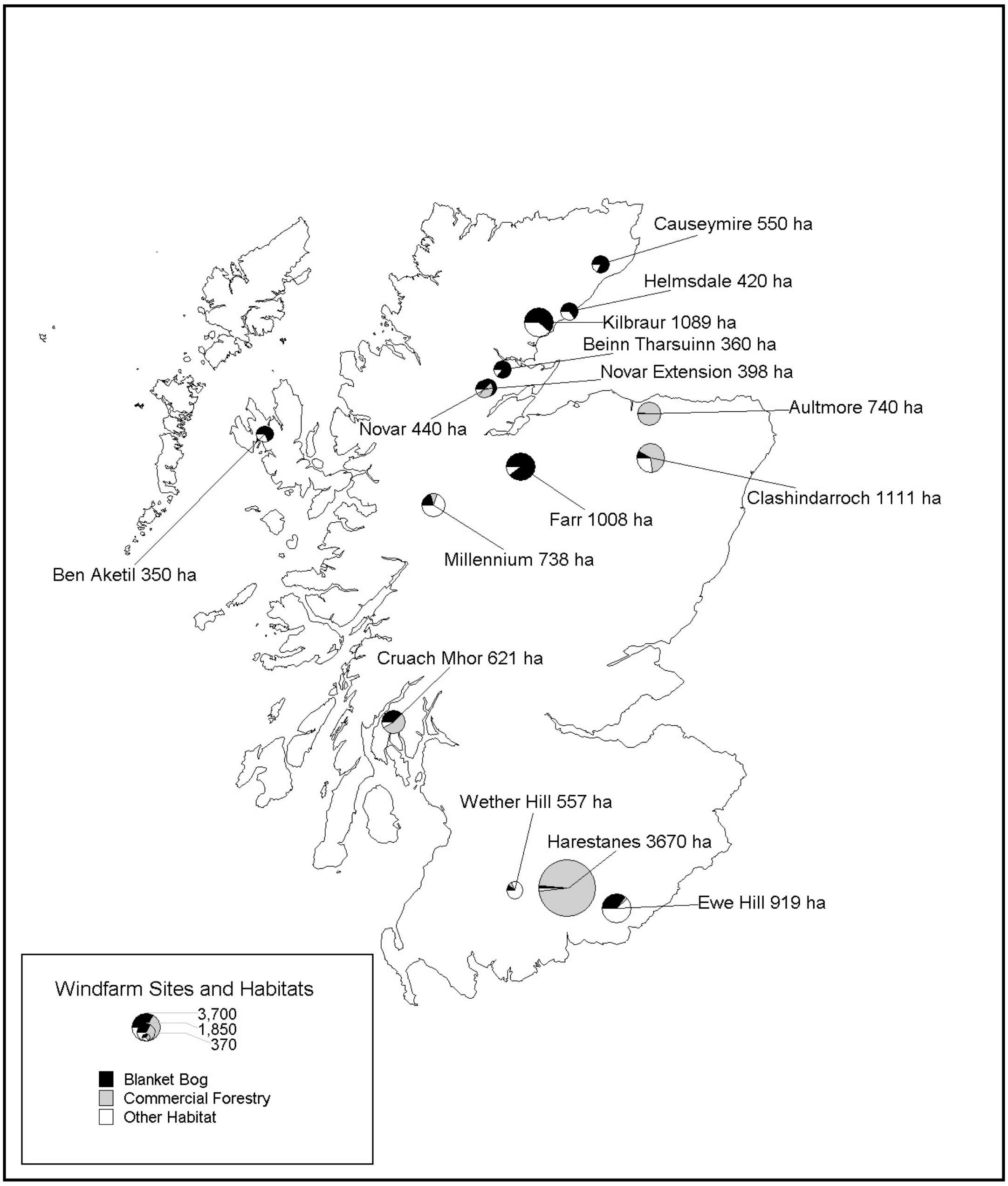

Figure 1 Windfarm sites covered in discussion

made at Novar (McLellan, Nicolson & Dargie, 1997). A cut road method was developed for 7.4 km of the site for use on steep longitudinal gradients and cross-slopes, producing the following benefits:

- good drainage with little erosion and minimised snow trapping;
- an upslope batter with near-total vegetation cover established in a very short time using turf blocks taken from the road corridor and stored temporarily adjacent to the work;
- a downslope batter with a rise from the verge to screen the road from below, significantly reducing visual impact; and
- removal of peat overburden for a relatively short distance for use in floating road construction, significantly reducing material movement and haulage costs.

A floating road method was developed for all gentle slopes (6.1 km of road length), using stone laid on geotextile to a depth of 700 - 800 mm. The vegetation cover either side of the road was stripped back for 4 - 5 m and a batter was formed from unwanted overburden derived from cut road sections. This disposed of 30,000 m^3 of peat. The stripped turf was then drawn back over the batters to provide a near-total vegetation cover and a road with reduced visual impact.

Both road types benefited from construction in the winter of 1996-97. There was little vegetation growth on high ground (close to 600 m OD), with no drought effects or significant frost damage.

Roads at Causeymire are all floating in design. Heavier and larger vehicles require a slightly wider running width (4 - 4.5 m, as against 3.5 m at Novar), with about 1,000 mm of stone laid on geotextile. The wettest ground at Causeymire has used two layers of geotextile. For much of the site, verges 4 - 5 m wide either side have been stripped back. These have been used temporarily for storage of peat and boulder clay from turbine bases, with excess overburden then used to form batters. This has not been done in very wet areas close to pool systems in order to avoid weakening the vegetated surface of the bog. Now almost at the end of construction, the Causeymire road remains floating for all but 200 m where it has sunk about 0.7 m into the bog and extra stone has been required. Electrical cables in this area have been laid in a very shallow, narrow ditch, which has been topped by a low mound of peat to achieve the required depth of burial.

Work at Novar required upgrading of 11.5 km of existing forest roads through Novar Estate and an additional 13.5 km of new road, much of it over severe terrain. The new road produced 5.4 ha of habitat loss (half of it blanket bog), together with disturbance either side in the road corridor (probably totalling about 10 ha, half of it blanket bog). Verge restoration has been very successful and a vegetation cover close to 100% is present over much of the site, very similar to adjacent intact blanket bog.

In addition to habitat loss and disturbance, roads have an impact on blanket bog hydrology. This does not seem to have been researched, but floated roads will result in some compression and a probably a modest change in hydraulic conductivity. Cut roads through blanket peat include a steepened upper slope, a side ditch, cross-drains at varying intervals and a zone of disturbance where water and occasional sediment is discharged. This is likely to result in drier conditions adjacent to much of the road corridor. However, most windfarm road length over blanket peat in Scotland built by Edward Mackay Ltd (constructors of 10 windfarms, including Novar and Causeymire) is floated and cut road impacts on hydrology largely affect wet and dry heath (E. Mackay, pers. comm.).

IMPACTS FROM TURBINE FOUNDATIONS AND CRANE HARDSTANDING

Turbine bases have to be founded on rockhead, requiring excavation of peat, boulder clay or other glacial material. There has been a major increase in the size of wind turbines in the last few years, as generating capacity has been increased. Novar Windfarm comprises 34 0.5 MW turbines, each with a 42 m high tower, a 34 tonne nascelle (hub height 45 m) and 27 m long blades. Erection required two mobile cranes, the largest with a 400 tonne lifting capacity. Causeymire Windfarm will comprise 24 2.3 MW turbines, each with a 60 m tower, an 87 tonne nascelle (hub height 64 m) and 40 m long blades. Erection requires two mobile cranes, one with a 1,000 tonne lifting capacity and 80 m long boom.

Work at Novar included crane hardstanding built on to bedrock within the normal road corridor and adjacent hammerhead parking area. A much larger area of separate hardstanding is required at Causeymire (about 40 x 20 m). Base excavations at Novar varied in size but were mainly of the order of 25 x 20 m in dimension, with bedrock within 2 - 3 m of the surface. Causeymire has involved excavations between 35 x 40 m for many turbines but up to 50 x 50 m for five turbines on deep and wet peat (3 to 3.5 m) and a variable thickness of boulder clay (0.5 - 3.5 m). The larger size includes a shallow batter angle for cut peat and use of a cofferdam stone structure around the turbine base, both to ensure safe working for men and machines.

Little pumping was required at Novar as part of excavation, due to dry blanket peat types and a spring and early summer (the period of turbine erection), with low rainfall. Pumping on a daily basis has been necessary for most excavations at Causeymire. The site lies adjacent to the River Thurso Special Area of Conservation (SAC) (notified for salmon interest) and planning conditions have included regular monitoring of suspended solids at nine silt traps, with all work to stop if levels exceed 25 mg / l^{-1}, re-starting only when the cause of high solids generation is identified. To comply with this condition, each base excavation has required an additional temporary silt pond to be constructed from straw bales and cloth geotextile and most of these have been very successful. A small number have had local overspill, affecting a few tens of square metres of bog surface which will in three cases transform an ombrotrophic surface of very low extent into something reflecting higher nutrition (probably *Molinia caerulea* cover).

The areas of ground affected by base excavations and crane hardstanding is about 2.4 ha at Novar and 3.9 ha at Causeymire.

After backfilling and replacement of a peat surface (leaving only the turbine base and a 1 m wide gravel surround), the ground at Novar was sown (summer 1998) with a grass - heather mix which has developed an average 81% vegetation cover in five years, with *Calluna vulgaris* and *Eriophorum vaginatum* now largely replacing grasses. A few turbines are slower, mainly due to sheetwash impacts from blanket bog upslope during heavy rain. One turbine base still has a low cover (17% in 2003) but this was sited at the head of an existing area of gully erosion in hagged peat. A higher cover here is being encouraged using planted tufts of *Eriophorum vaginatum* at 0.5 m spacing.

Restoration at Causeymire is not finalised but will probably use planting of blanket peat tufts, plus a mulch of *Sphagnum* fragments (a mix of *S. capillifolium, S. tenellum* and *S. papillosum*), all derived from adjacent ground. Crane hardstanding work will mix Caithness Flag gravel and peat that will be rolled firm and then sown with a mix of *Molinia caerulea* and *Calluna vulgaris*. Stock grazing should keep this short and smooth, allowing access by cranes when servicing turbines.

WINDFARMS VS OTHER IMPACTS ON BLANKET BOG

So, just how large might windfarm impacts on blanket bog be when aggregated for Scotland and then compared with other degrading influences such as those discussed by Coupar, Immirzi and Reid (1997)? Our only easy measure is a guesstimate of extents for habitat loss and disturbed ground that is restorable by habitat succession. This is a little inadequate and takes no account of habitat fragmentation or severance of wildlife corridors which might be present, though these are not likely to be major effects for windfarm developments which mainly use floating roads.

To formulate an answer requires a guess at the final number of terrestrial windfarms which might be established in Scotland (set here at 150), together with an average number of turbines per site (set here at 40), and assuming each turbine will require 460 m of road and a base excavation totalling 0.25 ha. A borrow pit of 1 ha extent is assumed to provide sufficient stone for roads and base excavations covering 15 turbines. Results are given in Table 1.

It is obvious that windfarm impacts are at least an order of magnitude lower than the three other major causes of degradation examined by Coupar, Immirzi & Reid (1997).

	Permanent habitat loss km^2	Restorable disturbance km^2
Windfarm roads[1]	14.0	28
Turbine bases[1]	0.1	15
Other infrastructure[1]	4.1	3
Total windfarm impact[1]	18.2	46
Postwar losses to forestry[2]	1290.0	
Losses to gully erosion[2]	2000.0	
Improved for pasture[2]	180.0	
Total blanket bog[3]	10680.0	

Table 1. Comparison of potential extents of windfarm impact and other degradation on blanket bog habitat.

Sources:
[1] Estimates based on 6000 turbines in Scotland, each turbine requiring 460 m of road and a base excavation of 0.25 ha,
[2] Coupar, Immirzi & Reid (1997),
[3] Lindsay & Immirzi (1996).

MITIGATION

Is it possible to offset blanket bog losses and disturbance due to windfarm impacts? Some environmental statements submitted to planning offer reasonable extents of habitat improvement via drain blocking (e.g. Kilbraur). Grazing pressure has been reduced substantially at Causeymire and a switch has been made to cattle as the main herbivore. Elsewhere, existing land ownership and land use make mitigation difficult, since developers usually only lease roads and permanent infrastructure after construction.

An exception has occurred at Cruach Mhor (Argyll & Bute) where hen harrier and short-eared owl interest required a management area to be obtained away from the windfarm for use as breeding and foraging ground. The developers have purchased adjacent ground (mainly young Sitka spruce, part of which shows checked growth due to high heather cover). The development will result in the permanent loss of 6 ha of blanket bog. This has been offset by felling and mulching 128 ha of conifers in the development area which, with management, should enable 108 ha of blanket bog to be restored using ditch blocking. Similar felling and mulching in the management area will restore a further 80 ha of blanket bog. The balance thus reads permanent loss 6 ha versus a long-term gain of 188 ha. Just a few similar examples could well offset much of the permanent losses at a national scale.

THE IMPORTANCE OF UNCERTAINTY

The conclusion above, that windfarms do not pose a serious risk to blanket bog habitat in Scotland, could change. Proposals for much larger developments in Scotland have been aired and at least one (Lewis Windfarm) includes a very large turbine total partly sited on ground of international importance for nature conservation (Lewis Peatlands Special Protection Area (SPA), but avoiding the Lewis Peatlands SAC).

A further complication has arisen recently, following a major landslide (bogalanche) at Derrybrien, Co. Galway, Eire in October 2003 (Fleming, 2003). Construction of the windfarm here (it will be the largest windfarm in Eire with 71 turbines) triggered a major earth movement which eventually affected 70 ha of very wet blanket bog and conifer plantation, releasing a very large volume of liquid peat into a narrow watercourse, damaging bridges, closing roads and probably eliminating the local fishery. A question on the risk of such an event occurring in Scotland has been asked in the Scottish Parliament and the Scottish Executive is likely to require geotechnical risk assessments to be produced for all windfarm developments sited on deep peat.

Only time will provide the final answers to the habitat impacts of onshore windfarms.

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