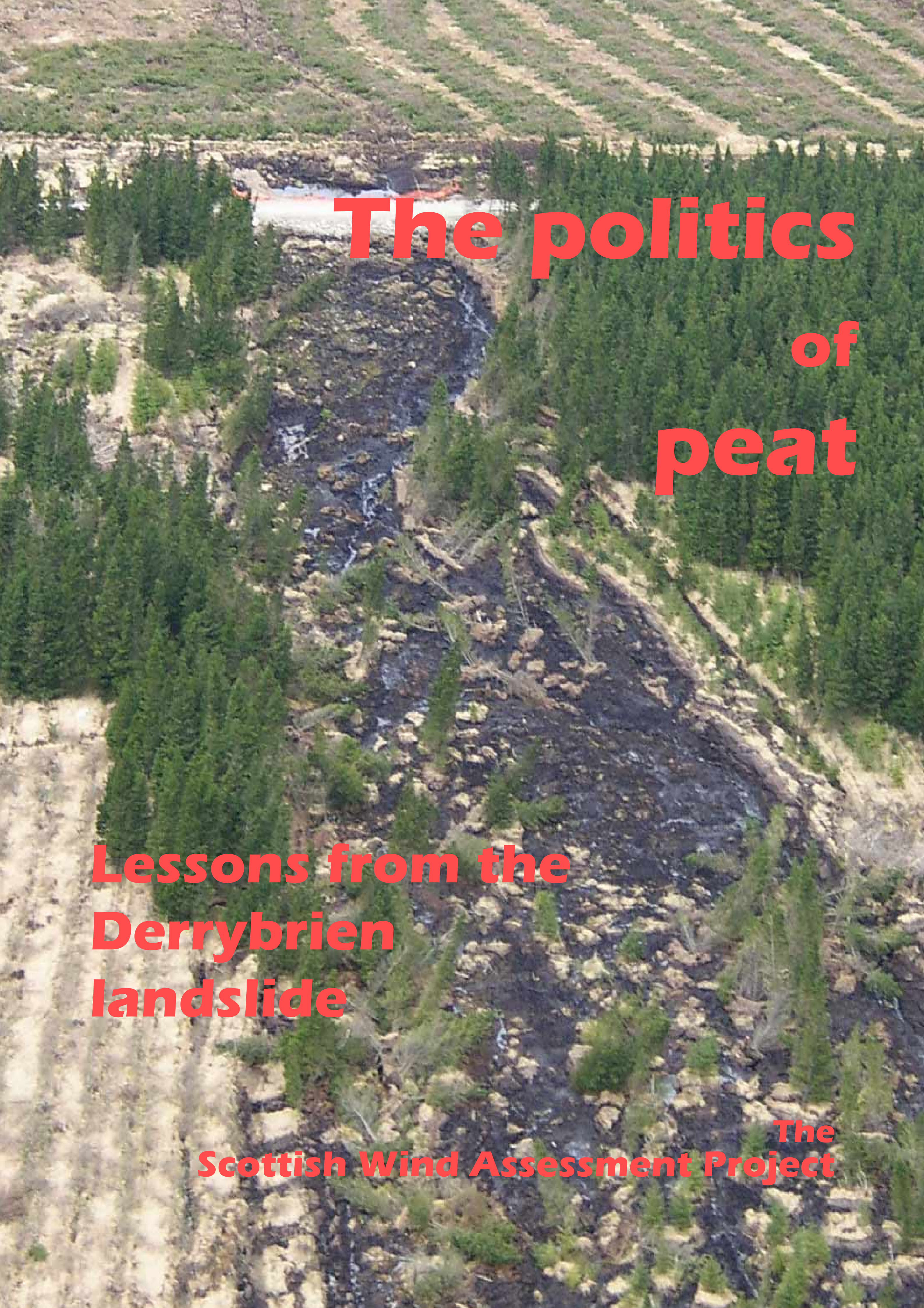


The politics of peat

Lessons from the Derrybrien landslide

The Scottish Wind Assessment Project

Plate 1: Cashlaundrumlahan from the south. The Gort-Potrumna road (see page 6) runs through the middle of the cultivation at the foot of the mountain (left to right in this picture). The slide occurred to the east of the village.

Published by the
Scottish Wind Assessment Project
July 2006

SWAP has produced a DVD using informative Radio Telefís Éireann news broadcasts of the incident and its aftemath. For copyright and size reasons, this cannot be distributed over the Internet but a limited number of copies can be obtained by contacting admin@swap.org.uk. Our thanks to library staff at RTÉ and to the sponsors who made it possible.

Contents

The Scottish Wind Assessment Project is a research programme which seeks to collate existing studies and commission new work to investigate claims made for and against the use of wind-generated energy and associated issues. It is supported by private donations. Contact via research@swap.org.uk. Its reports are posted on www.swap.org.uk.

COPYRIGHT AND ACKNOWLEDGMENTS

Thanks to JC, MC and JP for providing material for and invaluable assistance with this report, to RO for the graphics, to those who critically read the text and to those who generously provided photographs.

FRONT COVER

An aerial view taken at Cashlaundrumlahan on 16 April 2005 looking north to the site of turbine 68, the point of origin of the bog slide, showing 30-year-old trees still growing on displaced rafts of bog, 18 months after the event.

Introduction

THE DERRYBRIEN BOGSLIDE of October 2003 has particular relevance for wind-power applications scheduled for construction on peatland habitat, due not least to concerns on the part of planners about falling foul of European Union environmental regulations.

The incident initially attracted little interest in Scotland's wind-power sector but, as disparate groups of researchers and campaigners approached the European Union's environment commission, it began to catch the attention of advisors to local and central authorities.

Parallels between Derrybrien and many Scottish sites became increasingly hard to ignore and, before long, planners and the Scottish Executive's Consents Division were regularly calling for peat *risk* assessments as part of or, often, as *post hoc* supplements to, Environmental Impact Assessments (EIAs).

In the event, developers frequently submit peat *stability* reports which generally suggest micro-siting to avoid deep peat and slopes but do not assess the problem.

- Despite promoting wind power in its region, one of Scotland's largest planning authorities was last year forced on legal grounds to refer back an application originally consented in 2002 and call for peat risk assessment. Responding to third-party complaints, European environnmental authorities had queried the consent's propriety on procedural grounds.
- Also last year, the press reported a case where much of the text in studies for three markedly different sites hundreds of miles apart was not only identical but was shared with a report prepared for a different developer and site – including typing errors. The story has been corroborated – see box, page 9.

Researchers for the Scottish Wind Assessment Project have examined several of the assessments currently under review. It is clear that not only do they draw limited lessons from the Derrybrien events but that they have characteristics in common:


Plate 2: the first slide (16 October 2003) came to a halt by a recently vacated farmhouse about 1.5 kilometres from its origin. (See Fig 1, page 6).

On 28 October, following torrential rain, it flowed down a waterway into the Abhainn Da Loilioch river and 15km into Lough Cutra, an SAC. Fisheries authorities estimate that 50,000 fish died as a result.

- They rely almost exclusively for accounts of the incident on one report, that prepared by the project's developer, even though its remit was limited to the first of the two main site incidents. It did not discuss the second bog slide (October 28), the pollution of the Lough Cutra Special Area of Conservation or the extensive fish kill that followed.[1]
- Few refer to Galway County Council's report which did deal (briefly) with the pollution incidents and none examine a substantive report by two internationally-recognised peatland conservationists commissioned by local stakeholders.[2] The latter draws conclusions at odds with the developer's and questions the long-term viability of any wind-power development on peatland on both safety and environmental grounds.
- Even fewer seem to grasp either the significance of European law and the authorities' obligation to uphold it or the willingness of others to ensure that they do. Had a stakeholders group, the Derrybrien Co-operative Society Ltd, not brought the incident to the attention of the European Union's environmental authorities, it would almost certainly have been quietly forgotten once the customary reports had been noted, the nominal fines had been paid and the go-ahead to resume work had been nodded through.
- Little of the material discusses the particular behaviour of organic soils but tends instead to present a 'best case' scenario for a project with assertions about 'levels of risk' based on 'walkover' studies and the like.
- None of the assessments have made follow-up studies of the events nor have the Scottish environmental authorities visited the site in the intervening three years despite its importance. The reasons for this omission are not known. The only expert follow-up seems to be the one summarised below (page 10).

It is not generally understood even by many developers, that peat is an organic soil which, when disturbed, tends to dry out over time. This process releases significant quantities of CO_2 to atmosphere. Opinions differ as to the extent of this oxidation but even conservative calculations suggest a conflict between the stated aims of wind-power development (reduction of CO_2 emissions) and the reality of their construction on peatland.

Nor is it acknowledged that the extensive drainage without which the turbines cannot be erected on peat soils both reduces the stability of the habitat and leads to its degradation over time. As Lindsay & Bragg show, the attempt to construct Derrybrien without drainage failed and the site has since been aggressively drained. The experience was similiar at Cefn Croes (see pages 27-29). It is disappointing that environmental lobbyists are reticent on this.

In a similar vein, strident denunciations in Holyrood and elsewhere of those who voice concerns about peatslide suggest a degree of possibly dangerous complacency on the part of some decision makers.[3] They contrast with the proper public scrutiny that followed other landslides in Scotland in recent years.[4]

In short, while the Derrybrien incident has been extensively analysed, the primary accounts tend to be hard to obtain and, because they are (quite properly) technically specialised, have too limited a remit to be reliable as the sole source of information. However, many of the secondary sources are selective, not to say partisan.

There is a need for an account of the incident that sets it in its political, legal and environmental context. This report is an attempt to provide one.

---

1 Applied Ground Engineering Consultants for Hibernian Wind Power, *Reports on the Derrybrien Windfarm*, Feb 2004.

2 BMA GeoServices for Comhairle Chontae Na Gaillimhe, *Landslide at Derrybrien Windfarm*, Feb 2004;
Lindsay & Bragg for the Derrybrien Development Co-operative, *Windfarms and Blanket Peat*, Oct 2004.

3 'I am going to condemn a Mr Hodgson . . . He has been responsible for many scare stories, one of the most unpleasant of which is the threat that children might be swept away in an Aberfan-style disaster if turbines are erected close to villages or on moorland . . .' Alasdair Morrison MSP, Scottish Parliament, 6 October 2004.

4 Examples include the Sandwick, Shetland slide of September 2003 and the August 2004 incident at Lochearnhead, where 57 people had to be rescued by RAF helicopter. On June 14, 2005, *The Scotsman* had reported that: 'Experts are drawing up a list of 'high hazard' roads, which include a 14-mile stretch of the A9 between Dunkeld and Drumochter in Perthshire . . . The research was ordered by Nicol Stephen, [then] the transport minister, after three main routes were blocked when they were engulfed by landslides within a week of each other last August. Three times as much rain as normal fell that month in parts of Scotland.'

Summary of events

One of Ireland's largest wind-power sites is the Electricity Supply Board (ESB) scheme on Cashlaundrumlahan, the highest, at 368m, of the Slieve Aughty Mountains in Co Galway. A 71-turbine, 60 MW project built on 850 acres of blanket bog, it lies about a kilometre north of Derrybrien, near Gort.

Land for the venture was sold by the state-owned *Coillte Teoranta* (equivalent to the UK's Forestry Commission) to a private developer who, after obtaining planning consents and subsidy agreements, sold the project (though not the land) on to the state-owned ESB. After a complex and at times controversial planning and development cycle, construction started in the summer of 2003.

Three months into the project, on October 16, about half a million tonnes of bog began to slide from a turbine base on the south of the site down the hillside towards the Portumna-Derrybrien road before coming to a halt two days later about 1.5 km from its point of origin. (See map, page 6.)

Following heavy rain on October 28, the displaced peat again began to move. Contractors moved in at dawn to erect check dams and tried to divert water from the slide channel but to no effect. Uprooting thousands of trees, the displaced peat continued to slide into waterways east of the village before pouring into the nearby Abhainn Da Loilioch river. This carried the debris about 15 km downriver into Lough Cutra. Several hundred acres of farmland were despoiled and the fishery authorities reported that 50,000 fish choked on the sludge.

In the aftermath, the ESB and the local authority published reports acknowledging that site construction activity was to blame. ESB's engineering arm and the site contractor received small fines for pollution offences.

Community campaigners, frustrated by what they saw as official indifference to the issues raised by the case, appealed to the European Union's Environment Directorate-General to intervene. With a robustness that took many by surprise, the Commissioner has commenced legal proceedings against the Irish government, describing the incident in January 2005 as 'an environmental disaster'. The case is ongoing.

Plate 3. Below: peat from the bog slide, by now a thixotropic slurry, pressing on the Flaggy Bridge just east of Derrybrien on 29 October 2003. The watercourse is normally three to four metres below the road level. In the event, damage to the bridge was minor. Left: a road sign just east of the bridge.

See also plate 12.

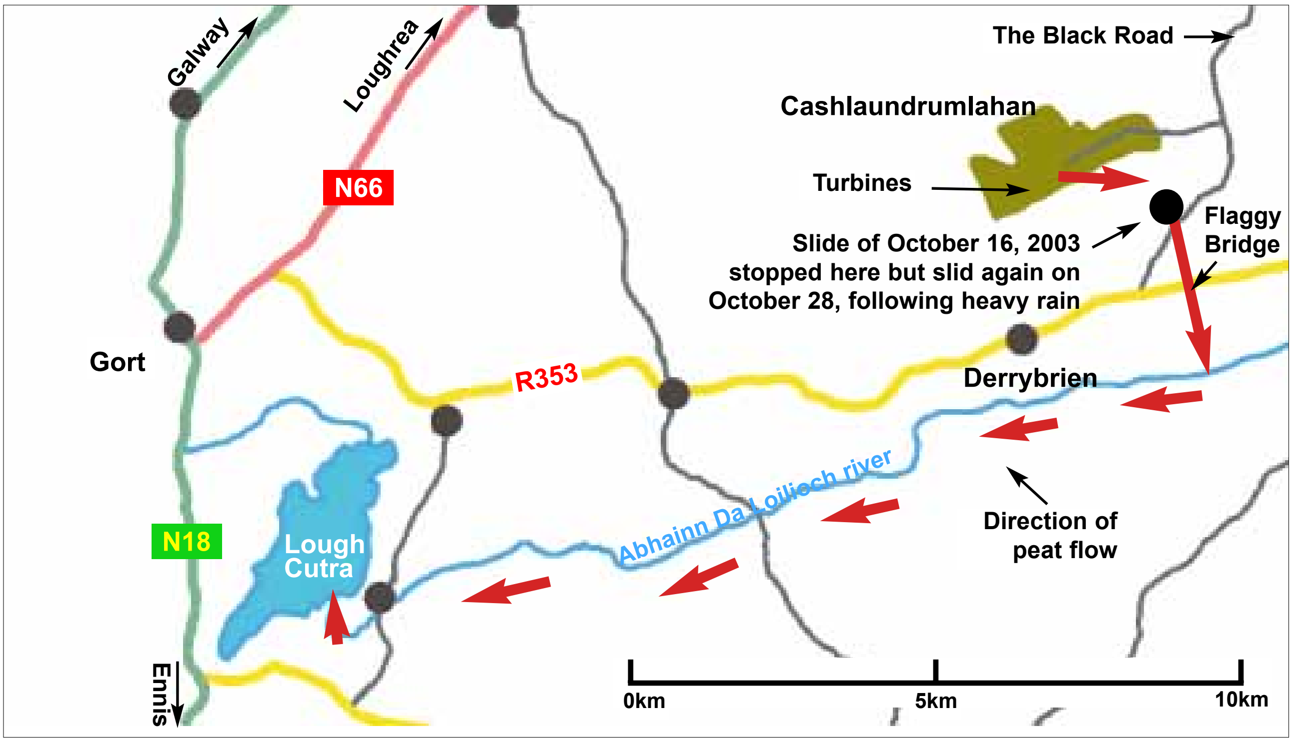


Figure 1: the approximate path taken by the bogslide from the base of Turbine 68 on top of Cashlaundrumlahan, down over the 'Black Road' linking Derrybrien to Loughrea, across the R353 Gort-Portumna road and into the Abhainn Da Loilioch river. It then flowed down the river course into Lough Cutra. Note the turbary road (access to traditional peat cuttings) heading west from the Black Road into the centre of the site. The Kilchreest peatslide was about 8 km to the north of this site. (Not all minor roads are shown here.)

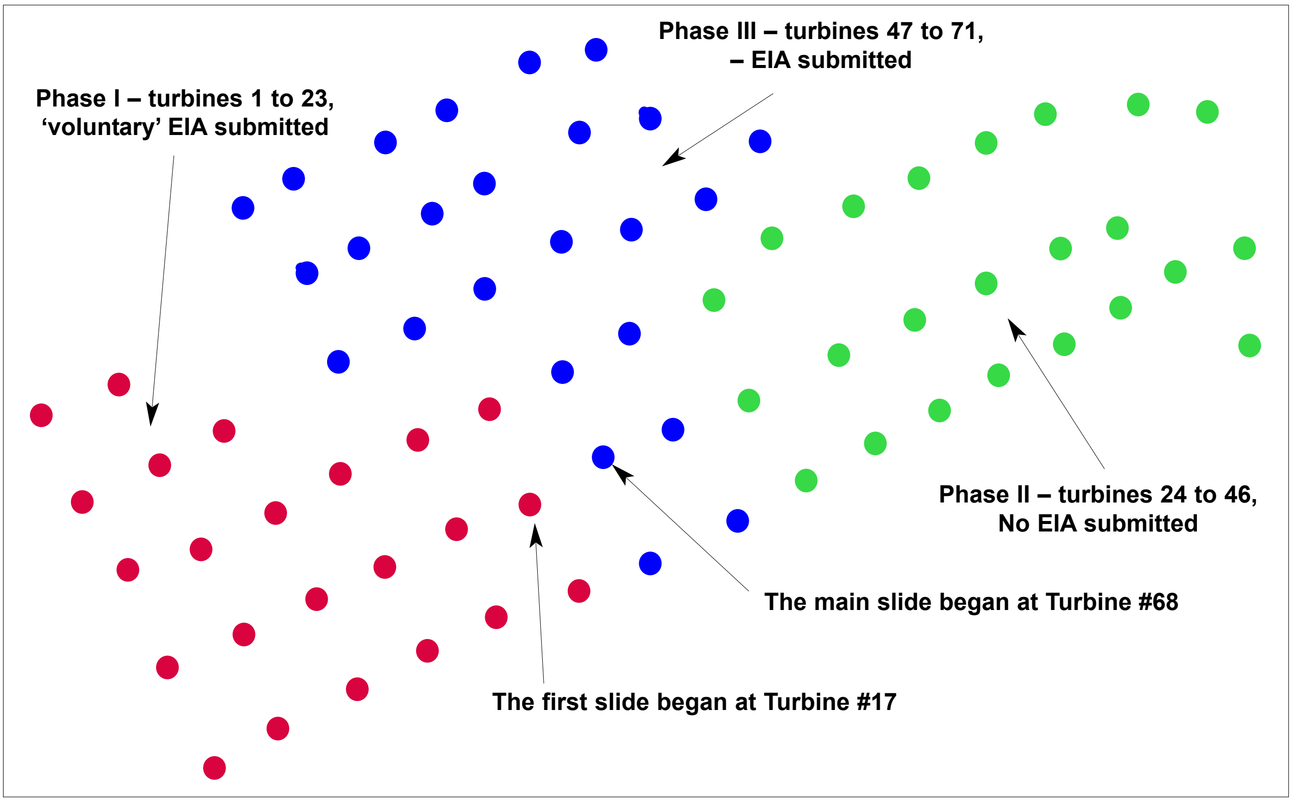


Figure 2: turbine layout for the Derrybrien site showing the three 'phases' by which planning consent was secured for an otherwise unitary 71-turbine project. Construction began with Phase III in July 2003 and the slides occurred the following October. Consent extensions were granted for Phases I and II in November just before the developer and the local authority received geotechnical reports on the incident. The project, now complete, was constructed in a continuous campaign.

EU Directives and the Derrybrien project

- **Derrybrien is a classic example of the avoidable damage that can follow developments which proceed without proper assessment. A substantial project on a sensitive peatland site was split into three applications, one of which was not assessed at all. The other two were subject to 'voluntary' assessments which, *inter alia*, failed to provide the necessary information concerning the risk to ground stability. All three were approved.**
- **These shortcomings were highlighted when construction triggered a bogslide. Although work halted while belated geotechnical assessments were conducted, the authorities, after considering the reports behind closed doors, permitted construction to resume.**
- **The EU's Environment Commissioner has begun legal proceedings against the Republic of Ireland over Derrybrien, alleging that it has infringed the EIA Directive by failing to ensure proper assessment.**
- **Examination of the European issues raised by Derrybrien shows that there are important lessons for Scotland where superficial ground stability assessments are also being routinely assessed behind closed doors.**

THE 71-TURBINE DERRYBRIEN project was consented after it had been presented as three separate planning applications (referred to as phases I, II, and III – see fig 2, opposite) along with supplementary applications for two quarries and a grid connection.[1]

On the face of it, it was a blatant case of 'salami slicing' an application (see page 19) but it requires a detailed examination of the procedures followed to determine whether it infringed the EIA Directive. For example, the applications for phases I and II were submitted while the directive was being amended (and so fell under the original regime) while the application for phase III was submitted after it was amended, thus falling under the new regime.

The amendment added explicit reference in Annex II of the directive to the need for assessment of 'installations for the harnessing of wind power for energy production (wind farms)'.[2] Hitherto, there had been no unequivocal requirement to screen these projects for assessment.[3]

The case took a further turn when the consents for phases I and II expired on 11 October 2003 and the developer applied for a time extension. This was granted on November 24, a matter of days after the bogslide.

The question arises as to whether granting a time extension to an existing consent constitutes 'development consent' within the meaning of the directive. The issue is certainly not clear. It had previously been held that, if a plan consented before the directive came into effect but which subsequently required a fresh consent (because scarcely any progress had been made in implementing the project), then that fresh consent required an assessment.[4] However, commenting on that case, Advocate General Jean Mischo remarked that 'Certainly there could be borderline cases where the earlier consent could be either very recent, replacement being necessary only for purely formal reasons . . . Perhaps the Court will be asked one day to rule on a question in such a context and refine the case-law as appropriate'.[5]

1 PL07.106437-12-10-1998, 23 wind turbines (600-750kw), hub height 48m; PL07.106290-12-10-1998, 23 wind turbines, hub height 45-50 metres; PL07.122803-15-11-2001, 25 turbines hub height not exceeding 50 metres and blade length 23 metres; PL07.106292-12-10-1998, 23 wind turbines and PL07.125978, June 2002, 48 wind turbines.

2 Council Directive 97/11/EC amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, OJ NO. L 073, 14/03/1997 P. 0005. The deadline for incorporation into national law was 14 March 1999.

3 Annex II of the Directive defines those types of projects which must be 'screened' on a case-by-case basis to ascertain whether they are likely to have significant effects on the environment. If they are, they must be subject to Environmental Impact Assessment.

4 C-81/96 Burgemeester [1998] ECR Page I-03923 para. 22-29. See also C-201/02, The Queen, on the application of Delena Wells v Secretary of State for Transport, Local Government and the Regions (2004), ECR page I-00723 para. 44-47, where a decision to extend an old mining permission was held to be a development consent subject to the EIA Directive.

5 Opinion in C-81/96 Burgemeester, para 54.

Habitats Directive breaches

Several proposed wind-power sites in Scotland are likely to affect SACs and/or SPAs.

A particularly close parallel to Derrybrien is a 100 MW project by Airtricity at Braes of Doune, near Stirling. Both projects are outside but in the catchment of SACs – in the Braes of Doune's case, the River Teith, designated to protect lampreys (*Lampetra fluviatilis, L. planeri* and *Petromyzon marinus*) and Atlantic salmon (*Salmo salar*).

Little attention has been paid to the importance of any proximate Natura 2000 sites either by the contractor or by the determining authorities on the grounds that they are distant from the site.

A failure to perform adequate assessment of peat stability at the Braes of Doune has left the potential impact on the River Teith SAC without appropriate assessment and Scottish Natural Heritage looking to straw bales to protect it.

That said, whatever the status of the consents for phases I and II, there is no doubt that phase III fell under the new regime and, according to the Commission, such assessment as was carried out was manifestly deficient in examining the risks to ground stability. A fresh assessment should have been undertaken before the decision was taken to resume construction work following the disaster.[6]

In the event, although construction was halted pending a new geotechnical report, the report formed the basis of a behind-closed-doors decision by Galway County Council to allow work to resume.[7] The Commission's position is that, regardless of the report's substance, the EIA Directive stipulates (article 6) that *the public must be consulted* on any environmental reports. This was not done.

The risk to designated areas

Although the Commission does not mention the Habitats Directive in its Derrybrien press releases, the disaster impacted directly on the Lough Cutra Special Area of Conservation (SAC) and Special Protection Area (SPA). The Directive requires that any project likely to impact on an SAC or SPA be subject to 'appropriate' assessment of those impacts.

This stipulation should not be confused with the requirements of the EIA Directive. As noted above, the European Court has ruled (a) that 'appropriate' in the context of the Habitats Directive means according to the best available scientific knowledge and (b) that the absence of any effects must be established beyond all reasonable scientific doubt.

The directive was in full force throughout the planning cycle for Derrybrien and, although it is not clear exactly when the affected areas were designated (i.e. before or during the planning process), this has little relevance.

6 Commission press release IP/05/37, *Ireland: Commission pursues legal action for breaches of environmental law in eight cases*, 13 January 2005.

7 Applied Ground Engineering Consultants Ltd, *Report on Derrybrien Windfarm – Final Report on Landslide of October 2003 – Final Report on Post-Landslide Site Appraisal, 2004*; BMA GeoServices Ltd, *Final Report to Comhairle Chontae na Gaillimhe: Assessment of Landslides at Derrybrien Windfarm Site*, Derrybrien, Co. Galway, 2004;

A failure to consult the public

In Scotland, instances of seemingly rubber-stamping ground stability reports behind closed doors have been identified. It is perfectly proper to assess minor construction details after public consultation but the practice of relegating substantive issues such as ground stability assessment to such a late stage almost certainly contravenes the EIA Directive. When the Commission wrote to the UK regarding the Edinbane project, Highland Council sought an opinion on the practice from European law expert Professor Jeremy Rowan Robinson. He wrote:

> **If the consequences for ground stability could be a 'main' or 'significant' effect on the environment, the consequences should be assessed before the decision is taken, any necessary mitigation measures should be proposed, there should be an opportunity for consultation about the assessment with the appropriate public bodies, the public should have an opportunity to consider the assessment and this information along with any representations with regard to it must be taken into account by the Council before they make the decision.**

But the practice continues. Examples include the recent decision to consent Ben Aketil subject to the condition that, 'prior to the commencement of development, a Peat Slide Assessment and Mitigation Statement shall be prepared and submitted to the Planning Authority for prior written approval . . .'

The Scottish Executive considered reports for both the Farr and the Braes of Doune sites behind closed doors.

Even if a project is already underway when a potentially affected area is accorded protection, the project still has to be assessed.

A risk to protected sites arises if they are connected to wind-power sites by watercourses. An influx of acid peat sediment such as followed the Derrybrien bogslide could – and did – damage habitats and the fish, birds and mammals that depend upon them.

The assessment submitted by the developer did not address the risk of peatslide on the SAC/SPA but commented that 'the main potential impact to water from this project is during the construction phase if run-off from earth works brings large amounts of suspended solid matter into local streams. This risk is low as construction methods will not involve the large-scale movement of peat, soil or rock'.

The failure to assess the risk to and protect Loch Cutra from damage is inconsistent with the Habitats Directive.

Pseudo-assessment

The practice of *pseudo-assessment* – subjecting a project to an ostensible assessment which does not in fact address its effects in a rational or site-specific way – has also been identified in Scotland.

Ground stability depends on the conditions at a particular site – peat is a particularly variable 'soil' type. Although its stability can only be assessed by measuring undrained in-situ shear strength, 'walkover' assessments which fail to consider local mechanical or hydrological properties are so commonplace that there is not space to list them but they include AMEC's Lewis project and Airtricity's Braes of Doune site.

Developer RDC submitted almost identical walkover reports for its Dunbeath, Kilbraur and Ben Aketil projects despite their wide separation and climatic differences. Close examination shows that key parts are almost identical to rival National Wind Power's assessment for its Farr project.

Plate 4: aerial views of the site showing the degradation caused by deforestation, 'floating' roads and peat excavation.

Two years on . . .

Moorland conservationist John Phillips, founder and former director of The Heather Trust, visited the Derrybrien site in July 2005 to see what lessons might be learned to prevent a repeat of the catastrophe at any one of several sites proposed for similar terrain in Scotland. He has submitted a report to Scottish Natural Heritage. SWAP is grateful for permission to publish these edited extracts. (The full report is on www.swap.org.uk.)

The area was ploughed around 1985 and planted with lodgepole pine *Pinus contorta*. Sitka spruce *Picea stichensis* and some self-sown *Salix* spp make up the tree species spectrum. Although ground rock phosphate was applied after initial establishment, the trees failed to grow at a commercial rate and Coillte was happy to abandon the site. To prepare for wind turbines, they had to be felled and, as a fire precaution, windrowed. None of the roundwood inspected exceeded 15 cm diameter at the butt and was apparently not worth taking off site. A small proportion was used to construct floating roads.

Quarrying

A 'borrow' pit excavated from within stratified limestone bedrock on the site (plate 10) was easy to work after an over-burden of two metres of peat and three of boulder clay had been stripped off. Its volume is estimated at 150,000 m^3. The biggest 'borrow' pit on the site, it has been been abandoned, not back-filled.

Floating roads

There are 'floating' roads throughout the site. The standard construction practice was to place a layer of felled trees in an interlocking mat on top of the acrotelm with 150mm of broken stone placed on top, purportedly to allow water to seep between the acrotelm and the layers above.[1] A sheet of geogrid/terram synthetic material was laid on top of the broken stone, followed by 400 to 500mm of crushed stone. Finally, it was faced with fines to create a smooth surface. The depth of imported material is thus about 800mm. Although an ancient turbary road on the site is of similar construction, it has been regularly faced over many decades and is now capable of carrying heavy traffic. In contrast, a length of road constructed in this way early in the project now lies a full metre below the surrounding bog (plate 5). As the road became waterlogged in places, the contractor had piled on more rock to raise its surface above the water-table, which increased the loading. The side-drains which have been dug beside the floating roads to remove waterlogging inevitably slice through the acrotelm, thereby removing this important protective layer and exposing the catotelm peat directly to the atmosphere. The first (October 2) landslip occurred alongside a floating road where the acrotelm had failed.

[1] The terms *acrotelm* and *catotelm* are defined in the glossary (page 30) and discussed on page 22.

Plate 5: a 'floating' road sinking quite rapidly into the bog and prone to flooding in heavy rains.

It comprises a layer of pole material covered with 150mm of broken stone (reportedly for drainage), a geosynthetic membrane and 500 mm of crushed rock finished with fines. About 800 mm thick, it weighs over three tonnes per running metre.

As these roads became waterlogged in places, their level was raised by adding more aggregate. This increases the risk of failure of the acrotelm.

Plate 6: a completed turbine base showing exposed peat which will oxidise and erode over time. While other projects propose different construction techniques, pollution and landslip risks will persist where peatland terrain is industrialised.

The turbine bases

While the area is superficially uniform, its underlying variability was revealed by the depths of peat and boulder clay encountered during construction. One turbine location had an overlay of five metres of peat and seven of unstable boulder clay over the bed-rock, necessitating the digging of a 12-metre hole to get the turbine keyed into a solid base. During construction, the continuous pumping-out of turbid seepage water was necessary. The average depth of boulder clay lying on the limestone bedrock is five metres and, at one point, boulder clay nine metres deep was encountered. This had all to be excavated and disposed of. As a matter of course, sound mineral material had also to be imported from the 'borrow' pits to back-fill each hole, secure the turbine and bring the base-ring up roughly to ground level.

The tower bases give the appearance of the work being only half-finished with a mass of crushed limestone on top of the concrete plinth dished into the foot of the steel work. The angle of repose of much of this material is inadequate and in places it is actively moving (plate 6). The same can be said for the surrounding peat banks. Although these have been battered to an angle of around 45 degrees, they are crumbling into the base drains. These have often been drawn in soft boulder clay, have no sound foundation and have eroded, leaving the peat bank undercut. The implications are serious: unless the tower bases are back-filled and sealed up with peat and the surfaces re-vegetated, the surrounding peat will dry out, break away from the parent mass and oxidise. Carbon dioxide will be released in large amounts (plate 7).

At almost every tower, peat and boulder clay had been dug out and either side-cast onto adjacent undamaged blanket bog or stacked on cut-over forest and left rough. The contractor later levelled this spoil, chamfering the edges to smooth out the landform. It will oxidise over the next decade or so (plate 8).

The aftermath of the bog slide

The reaction of the developer to the incident can be summed up as 'Be seen to do something'. Cosmetic work is still being carried out 22 months after the incident.

- On the site's access road, two diggers were seen taking peat sludge and mineral sediment out of the bed of a stream and laying it on top of native vegetation in the form of a large plateau of structureless material 1.5 metres deep. Operators claimed that, 'When it dries out a bit, we'll throw some hayseed on it and it'll grow and hold the peat'. It won't.

- Nearby, the stream had small barley-straw bales laid into the stream bed and weighted down with stones. These are intended to catch silt but are, and always will be, demonstrably ineffective – see page 14.
- A causeway forming a dam designed to hold back some of the collapsing bog was inspected. Here, 20,000 tonnes of rock had been quarried from a 'borrow' pit opened for the purpose. Almost half a million tonnes of material had passed the spot only two years previously and the causeway was holding up no more than 100 tonnes of slurry on its up-side. Anyone walking upstream could see that all that remained were a few tumbled trees with root-plates holding limited quantities of peat and boulder clay. The rest had gone.
- During the past months, a side-trench had been dug alongside the landslip to catch water seeping into the main watercourse. This was now coming down alongside the access road and undermining it. It will take only a winter storm of medium intensity to render it impassable to wheeled vehicles.
- Another bund has been built about 300 metres downstream at a point where the gorge narrowed and slurry had cascaded through at a depth of 10 metres. It was five to seven metres high and the peat lagoon behind it was some 50 metres long. Against the bund, the slurry was up to four metres deep and about 15 wide. An excavator was baling it out and placing the slurry into a 15 by 25 metre lagoon constructed alongside. It had high peat sides laid on top of deep blanket bog. This too will dry out and oxidise.

Plate 7. Top left: the drainage channel for a turbine base; the boulder clay under the peat is clearly visible. Top right: in several places on the site, boulder clay exposed in this manner is already eroding, leaving peat high and dry. Above: the drainage arrangement for turbine bases. Silt in the stagnant pools is to be trapped by silt beds (see pages 14 and 29).

Plate 8: two turbine bases at Derrybrien (middle foreground and top right) awaiting mineral backfill. Note the 'floating' access track, mineral-filled drainage, cable trenches and extracted peat laid on top of intact blanket bog, where it will dry out and oxidise over time. The remaining conifers have since been felled.

Plate 9: a 'silt trap' at Derrybrien made from barley-straw bales. These are, and always will be, demonstrably ineffective. Water at the low current flow prevailing on the day of the visit was running through the stones in the stream-bed with little, if any, running through the straw. None of the considerable amounts of suspended matter being carried downstream even at this low flow was being trapped.

When flow levels are significantly higher, the bales will be pushed out of the way by the weight of water and the increased load of suspended matter from upstream will again go straight down the watercourse. Two displaced bales can be seen on the top left of the picture.

The Scottish Environment Protection Agency has reportedly advised SNH that proposals to trap silt emanating from Scottish wind-power developments by using straw beds are satisfactory (see also plate 15). However, the Derrybrien experience confirms that, even at a distance from the bog slide, drainage works essential for the site's operation increase the turbidity and silt load of streams and that disturbance of the peat results in increased oxidation and the release of greatly increased levels of humic acids.

In practice, there are no techniques available to mitigate damage downstream caused by deposits of suspended matter.

Two important points about using straw as a filtration medium are a) that regard must be paid to eutrophication caused by decomposition of the straw used in the beds and b) that, to maintain effectiveness, the straw would have to be renewed at least every eight weeks even under normal rainfall patterns and the regime needs to be maintained more or less indefinitely and certainly at least until decommissioning.

Flow levels in Scotland's streams regularly vary by a factor of 300 within a season. It is self-evident that straw beds, however large or numerous within a catchment, will not cope with run-off generated by storm rainfall where several centimetres of rain can fall in a matter of hours. There is, quite simply, no way that straw-filled lagoons and filtration beds will cope with the quantity of suspended matter carried downstream off disturbed ground under storm conditions such as these.

Derrybrien – a chronology

The chronology of events at the Derrybrien site is complex even by the arcane standards of the renewables industry: it took eight years from the time of the original planning application to complete the project. In the light of the European Union Environment Commissioner's intervention in the case, the sequence of events is informative. It is outlined below. (The stakeholders are detailed on page 18.)

Dec 1997	Saorgus Energy submits applications to Galway County Council (GCC) for two wind-power projects on adjacent sites at Derrybrien, each for 23 x 0.66 MW turbines with 50m hub heights & 23m blades. Phase I was supported by what was described as a 'voluntary' Environmental Impact Assessment (EIA) but there was no EIA for Phase II.
Jan 1998	B9 Energy Services applies to build another project on nearby private land (25 x 0.66 MW).
12 Mar 1998	GCC consents Soargus Energy's two projects. Local objectors appeal the decision.
26 Mar 1998	GCC consents 23 of B9 Energy's 25 turbines. The project was later abandoned.
12 Oct 1998	An Bord Pleanala (ABP) upholds GCC's decision subject to 12 new conditions.
1999	GCC grants Soargus Energy permission to construct a 110kV grid connection for the site.
5 Oct 2000	Saorgus Energy applies to GCC for a third 'phase' comprising 25 x 0.85 MW turbines with 60m hub heights and 30m blades. The ES is broadly the same as that produced for Phase I.
1 Dec 2000	GCC rejects the application after planners cite breaches of the EU Habitats Directive and inadequate EIA. Saorgus Energy appeals to ABP.
15 Nov 2001	ABP overturns GCC's decision but imposes 13 conditions including reduced hub heights.
4 Feb 2002	The Department of Public Enterprise awards Saorgus Energy a contract under Ireland's Fifth Alternative Energy Requirement scheme (see page 30).

Plate 10: a 'borrow' pit used for quarrying rock for access tracks and turbine bases. This one lies a kilometre to the north-east of T68, the point of origin of the slide. Note the peat 'lagoons' on the top and left of the picture.

4 Oct 2002	Saorgus Energy applies to GCC to increase turbines sizes for all three phases to 0.85 MW.
27 Nov 2002	GCC approves the change.
Jan 2003	Saorgus Energy applies to the Forest Service for consent to deforest 650 of the site's 850 acres.
May 2003	Coillte Teoranta is granted consent to deforest the site.
Jun 2003	Coillte Teoranta sells the site to Saorgus Energy.
2 Jul 2003	Construction starts on Phase III.
9 Jul 2003	The Department of Communications, Marine and Natural Resources awards Saorgus Energy an AER VI contract for the Derrybrien site.
Jul 2003	Saorgus Energy sells the three projects as Gort Windfarms Ltd to ESB subsidiary Hibernian Wind Power (HWP). It retains ownership of the land.
1 Oct 2003	Gort Windfarms appplies to GCC to extend planning permission for Phases I & II.
2 Oct 2003	There is a small peat slide (~2,000 m^3) during excavation for T17, 230m west of T68.
11 Oct 2003	The planning consent for Phases I & II expires.
16 Oct 2003	The first bog slide begins at 16.00 hrs approx. By 18 October, the peat has settled about 1.5 km below the point of origin. Construction work is suspended.
28 Oct 2003	The second bog slide: following heavy rain, the peat moves again, closing roads and flowing down water courses into the Abhainn Da Loilioch river upriver from Lough Cutra, an SAC.
31 Oct 2003	Fishery officers begin digging dead fish out of peat sludge in Lough Cutra.
3 Nov 2003	The Derrybrien Landslide Action Group (DLAG) visits Brussels to lodge a complaint with the Environment Directorate-General (EDG).
14 Nov 2003	RTE reports an earlier, smaller bog slide at a wind-power site at nearby Kilchreest. The Shannon Regional Fisheries Board, reporting 50,000 fish deaths in Lough Cutra, fears biodiversity loss and long-term damage to protected species. 'The . . . Board is concerned that this is the third peat landslide to occur in the region over the last 18 months. These three incidents occurred in areas where active development was taking place.'
21 Nov 2003	The EDG registers DLAG's complaint.
24 Nov 2003	GCC extends planning consent for Derrybrien Phases I & II.
5 Feb 2004	HWP publishes AGEC's report into the slide. It highlights construction activity as the root cause but suggests that construction continues subject to 17 recommendations.
13 Feb 2004	GCC publishes BMAG's report, which cites over-pumping, drainage changes and vibration as possible causes of the peat slide.
28 Jun 2004	HWB announces that work is to recommence.
20 Jul 2004	The EDG sends the Irish government a 'Letter of Formal Notice' alleging several infringements of European environmental law. It requires a reply within two months.
Oct 2004	GCC grants Gort Windfarms an extension to the 1999 grid connection consent.
21 Oct 2004	ESB International and contractor Ascon are convicted of polluting the Abhainn Da Loilioch river and fined €1,250 (~£900) each. Fish kill charges are dropped on technicalities.
26 Oct 2004	The Derrybrien Development Co-operative Society publishes the Lindsay & Bragg report.
5 Jan 05	The EDG sends the Irish government a Reasoned Opinion over Derrybrien, in effect its final written warning.
Mar 2005	GCC grants Gort Windfarms a further extension for Phases I & II.
11 Apr 2005	The EDG announces that it to prosecute the Irish government over Derrybrien and other incidents. Ireland's environment minister attacks what he calls the EDG's 'extraordinary discourtesy' in publicising the move before informing the Irish authorities. The case continues.
3 Jun 2005	The Derrybrien Co-operative Society seeks a High Court injunction to halt deforestation on the grounds that it is unauthorised. By the time the case is heard, deforestation is all but complete. The judge rejects the bid.

Plate 11: the effect of afforestation on the site. Top: delaminated ribbons of peat at the edge of the area where the slide occurred – there are few protruding roots. Above: just below T68, at the west side of the slide site. Rafts of surface vegetation detach along forestry plough lines.

Derrybrien – the stakeholders

An Bord Pleanala – Ireland's national planning appeals authority.

Applied Ground Engineering Consultants (AGEC) – a geotechnical consultancy. It prepared a report on the bog slide for Hibernian Wind Power and has acted as consultant to developments in Scotland.

Ascon – the site's design and build contractors. Established 1958, holding company Ascon Contractors Ltd and its two operating companies, Ascon Ltd (Civil Engineering) and Rohcon Ltd (Building), form one of Ireland's largest contracting groups.

B9 Energy Services Ltd – an Antrim-based developer. It applied to erect 23 turbines on a site leased from local landowners, a project later abandoned.

BMA GeoServices – a geotechnical consultancy. It prepared a report on the bog slide for Galway County Council.

Coillte Teoranta – established under the Forestry Act (1988) as an independent commercial state company, it is successor to the Department of Industry's Forest Service. It sold the land for the Derrybrien project to Saorgus Energy and contracted to fell and dispose of the timber on 650 of the site's 850 acres.

Department of Communications, Marine and Natural Resources – issued Alternative Energy Requirement (AER) licences (Round 6) in 2003 (see page 30).

Department of Public Enterprise – issued AER licences, Round 5.

Derrybrien Development Co-operative Society Ltd – a co-op formed some years ago by around 60 local residents.

Derrybrien Landslide Action Group – a Local Action Group associated with the Derrybrien co-operative.

Electricity Supply Board (ESB) – a statutory corporation founded in 1927 and still Ireland's largest electricity supplier. Its subsidiary, ESB International, is a utility engineering, contracting and consultancy business.

Environment Directorate-General, European Union (*EDG*) – formal title of the EU's Environment Commission. Its main role is to initiate and define new environmental legislation and to ensure that agreed measures are put into practice in the Member States.

Forest Service – a national authority run by the Department of Agriculture and Food. Responsible for the issuing of Felling Licences and for ensuring adherence to forestry legislation.

Galway County Council (GCC) – the local planning authority.

Gort Windfarms Ltd – a wholly-owned subsidiary of Hibernian Wind Power and effectively its local management arm.

Hibernian Wind Power Ltd (HWP) – a wholly-owned subsidiary of the ESB.

Irish Peatland Conservation Council – an environmental NGO which works to preserve Ireland's peat bogs. It is critical of the lack of a viable strategy for renewable energy in Ireland.

Irish Wind Energy Association (IWEA) – Ireland's wind-industry trade body.

Lindsay & Bragg – Richard Lindsay and Dr Olivia Bragg of the University of East London. They prepared a report on the bog slide for the Derrybrien Development Co-operative Society Ltd.

The National Parks & Wildlife Service – part of the Department of the Environment, Heritage & Local Government. It manages Ireland's nature conservation responsibilities under national and European law.

Saorgus Energy Ltd, founded in 1993 as Western Windpower, was the site's original developer. It sold the Derrybrien project to Hibernian Windpower in June 2003 but retained ownership of the land.

Radio Telefís Éireann (RTÉ) – Ireland's public service broadcaster covered the Derrybrien incident in some depth. Its library provided the clips for the DVD that accompanies this report.

Shannon Regional Fisheries Board – the competent fisheries authority for the inland fisheries and sea angling resource of the Shannon Catchment and surrounding region.

Annexe 1 – EU Environmental Directives

The environmental policy of the European Union has developed over the years into a far-reaching legal framework whose development is ongoing, with significant additions still in the process of implementation.[1] The core instruments are 'European Directives' which define minimum standards of environmental protection that Member States must implement in their national laws. If they fail to do so, they may find themselves called to account before the European Court of Justice.

Three directives in particular are relevant to the Derrybrien project and to many, if not most, of the proposed wind-power developments in Scotland. Their role is outlined here.

The Environmental Impact Assessment (EIA) Directive

THE EIA DIRECTIVE CONCERNS 'sustainable development'.[2] It places on Member States a duty to perform prior assessment of the consequences of any development likely to have significant effects on the environment. Aiming to avoid or minimise negative effects at the outset rather than trying to counteract them later, it lays down planning procedures that must be followed for any development with the potential to damage the environment. The bare bones of these are:

Scoping – a procedure for deciding which possible effects of a project require assessment and therefore the content of an Environmental Statement. It is a crucial stage of the procedure and the first where many EIAs fail because they do not identify the correct issues to examine.

Assessment – the possible effects of the development must be studied and an expert report (the 'Environmental Statement') produced. Although the EU stipulates that an ES must include comprehensive assessment of 'indirect and cumulative impacts and impact interactions' (and provides a wealth of guidance), it is often one of the most poorly-undertaken parts of an EIA.

Consultation – both the public and expert bodies must have an opportunity to give their views on the Environmental Statement;

Informed decision – the Environmental Statement and any other relevant information (including the views of the public) must be taken into account before deciding if or how the development should proceed.

How the Directive is circumvented

Implementation of the Directive has been resisted by some Member States. Although its 'stitch-in-time-saves-nine' approach reduces costs in the long run, developers tend to focus on short-term profit and sustainable development undoubtedly increases the initial costs of a project.

Similarly, administrations tend to focus on the delivery of short-term policy priorities whereas the Directive increases the time to decision. They can therefore perceive its procedures as an obstacle to their plans, something to be avoided wherever possible, and are frequently tempted to circumvent it either by exempting projects from assessment entirely (exemption) or by 'rubber-stamping' assessments which fail to address the potential impacts in a realistic way (pseudo-assessment).

Common to both methods of circumvention is the practice of 'salami slicing' large projects into smaller ones. These are then either superficially assessed in isolation (without regard to their cumulative impact) or are said to fall below the threshold above which assessment is required.

1 See, e.g. Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage.

2 Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, amended by Directives 97/11/EC and 2003/35/EC.

Plate 12: downstream from the Flaggy Bridge just east of Derrybrien two days after the second slide. Inset: the same view two years later. The contrasting pictures suggest the scale of pollution caused by the bog slide.

In extreme cases, a project may be split into several smaller applications each of which falls below the appropriate threshold. In this way, projects likely to have significant effects can escape assessment altogther.[3]

The practice is incompatible with the Directive, which refers to consent for projects rather than planning applications. It takes advantage of the fact that environmental impact of a project is a function of, amongst other things, its size. Slicing a project into parts which are then considered in isolation generally makes it easier to argue that the effect of each part is acceptable and tends to diminish the project's apparent overall impact.[4] Salami slicing is thus intimately linked with the issue of cumulative impact assessment.[5]

Over the years, the decisions of the European Court have made it more difficult to circumvent sustainable development procedures by granting exemption.[6] As a result, administrations have come increasingly to rely on pseudo-assessment and multi-stage consent procedures.

In the latter case, the public is consulted only during the initial stages of the planning cycle. The competent authority then grants consent subject to conditions. Thereafter, the determination of these conditions goes on behind closed doors even when the authority is assessing 'main effects' such as ground stability.[7] The public is thereby effectively deprived of its statutory right to participation in critical stages of the process.

Some administrations seem to regard *any* public participation in assessment as an obstacle. Common methods of circumventing it include the withholding of environmental information during consultation (pseudo-consultation) and restricting the right of appeal to developers only.[8] Administrations typically cite

3 See e.g. C-392/96, Commission v. Ireland (1999) ECR I-5901, para. 82.

4 In Scotland, quarrying activities associated with wind power projects are frequently the subject of separate applications. These may then be held to fall below the threshold for assessment – see, e.g. AMEC's Edinbane project.

5 A notable local example of salami slicing is the project to develop and upgrade the Lewis to Denny (and beyond) electricity transmission line.

6 See, e.g. European Court of Justice, Judgement in Cases C-72/95, Kraaijeveld BV v. Gedeputeerde Staten an Zuid-Holland; C-227/01, Commission v Spain; C-392/96, Commission v Ireland.

7 Local examples include the peat stability assessments for Braes of Doune and Ben Aketil. See also C-508/03, Commission v United Kingdom paras 102-4. The ECJ held that the UK had failed to implement the Directive into domestic law regarding multi-stage consents.

8 The public was not consulted, for example, on AGEC's ground stability assessment for Derrybrien or on Mott MacDonald's peat reports for Airtricity's Braes of Doune project in Scotland.

expediency and the national interest as reasons for behaving in this way.[9]

To counter these abuses, the Commission has strengthened the public participation provisions of the Directive.[10]

Its measures, which came into effect in June 2005, include a third party right of appeal on the procedure *and* substance of EIA decisions. By offering an incentive to avoid appeals, pseudo-assessment and pseudo-consultation are discouraged.[11]

The amendment should have been transposed into Scottish law no later than June 2005 but, as of June 2006, it has not been.

Procedures or results?

The EIA Directive lays down a procedure for environmental assessment in the hope that enforcement of the procedure will produce the desired result. Frequently, it doesn't.

The Habitats and Birds Directives, on the other hand, enforce both a procedure *and* a result – such as the conservation of a Natura 2000 site.

This is their strength compared to the EIA Directive: if a development means that the conservation interest in the designated site will not be maintained, then it cannot proceed.

The Habitats and the Birds Directives

Whereas the EIA Directive aims to minimise damage rather than proactively to conserve the environment, the Habitats and the Birds Directives have the positive objective of conserving and enhancing the wild flora and fauna of the European Union.[12]

The regime they impose is altogether more stringent. Their fundamental tool is the designation of areas which represent the best examples of European flora and fauna as Special Protection Areas (SPAs) for birds and Special Areas of Conservation (SACs) for other animals and flora. Collectively, they are known as the Natura 2000 network.

These areas are protected and managed in order to secure the survival of the species and flora in question: any activity which may jeopardise their integrity must be subject to prior assessment. Despite a similarity in terminology, the assessment required by the Birds and Habitats Directives is not to be confused with the procedures of the EIA Directive: it must be an 'appropriate' assessment, it must be conducted in the light of the best available scientific knowledge and there must be no reasonable scientific doubt regarding its conclusions.[13]

If an appropriate assessment finds that, or leaves any reasonable scientific doubt that, an activity is likely to have a significant adverse effect on a protected area, then permission must be refused.[14]

Unlike the EIA Directive, the Habitats and Birds Directives give effect to the full force of the 'precautionary principle' of European environmental law: development cannot proceed unless it is conclusively proved that it will not damage protected areas.

- A development does not have to be within a protected area for it to be deemed to have a significant effect: for example, a project outwith the boundary of a designated area may pollute or divert water feeding a river or loch designated as a Special Area of Conservation.[15]

9 See e.g. Scottish Executive, *Planning White Paper*, 2005.

10 Directive 2003/35/EC providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment and amending with regard to public participation and access to justice Council Directives 85/337/EEC and 96/61/EC.

11 UNECE, Guidelines on Access to Environmental Information and Public Participation in Environmental Decision-making.

12 Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora; Directive 79/409/EEC on the conservation of wild birds.

13 European Court of Justice, Judgement in C-127/02, Wadenzee and C-6/04, Commission v United Kingdom.

14 The only exception is where no alternatives exist and the activity is of an over-riding national importance ('imperative reasons') sufficient to outweigh the aims of the Directives, such as a vital port where no suitable facility exists outside a protected area. Where a protected area is designated for a 'priority habitat' type (such as active blanket bog), socio-economic reasons may *not* be taken into account and only reasons such as a human-life-critical emergency can justify damaging a protected area.

15 See C-98/03, Commission v Germany: German law was deemed defective as it allowed projects outside Natura 2000 sites to proceed without assessment even if their potential to impact on a designated site could not be excluded.

Annexe 2 – The mechanics of peat

The peatlands of the UK hold more carbon than all the forests of Britain and France: it has been estimated that there are 23,600 sq km of peat in the United Kingdom.[1] If its average depth is modestly estimated at a metre, this is nearly 24,000 million tonnes of material including 4,840 million tonnes of CO_2, equivalent to nearly all the CO_2 emitted in the UK over the last 10 years. By any reckoning, they are significant carbon sinks as well as a precious environmental asset. Nevertheless, as Derrybrien suggests, developers may not appreciate that they are potentially an unstable habitat. This note outlines the characteristics of a peat bog.

A PEAT BOG BUILDS UP over many years through the gradual accumulation of plant remains under waterlogged conditions which prevent aerobic activity and hence decay. Given a typical annual growth rate of one to two mm, peat several metres deep testifies to the often considerable age of bogs.

Waterlogging is a function of location: a depression in the landform may lead to the formation of a semi-permanent water body and the development of basin peat.

In lowland areas, purely rain-fed systems can develop mounds of peat several metres deep. These mounds are known as 'raised bog'. Some raised bogs in northern England, Latvia or Sweden are over nine metres deep.

Where rainfall is sufficiently regular, waterlogging of dead plant material can occur even on plateaux or gentle slopes, leading to the development of rain-fed or bog peat that typically occurs as a thick layer that blankets entire landscapes (hence the name blanket bog). It can reach thicknesses of five metres or more.

Blanket mire is often shallower than raised bog because the higher rainfall results in more oxygen flow in the peat and thus more decomposition.

Peats vary in character depending on the conditions under which they were formed. Basin peats formed beneath lime-rich water will yield a mull humus of neutral or alkaline pH. Blanket and raised bogs tend to be formed under conditions that depend on rainfall and are more usually acidic in character, forming a mor peat on the acidic side of pH neutrality.

The absolute amount of rainfall is critical but so too is the number of rain-days in the course of a year: frequent precipitation, even if it is light, helps to maintain soil capacity and hence waterlogging. Under normal conditions in the British Isles, it is typically only during June, July and August that the transpiration of water by plants in a peat bog exceeds the rainfall. It is thus only during these months that the top levels of the bog are sufficiently aerated to allow aerobic decay (which releases CO_2) and the production of water-soluble humic acids. It is these that make water from peaty areas pale brown in summer but clear in winter when the temperature is lower, bacterial activity is reduced and the peat is more highly saturated.

The anatomy of a peat bog

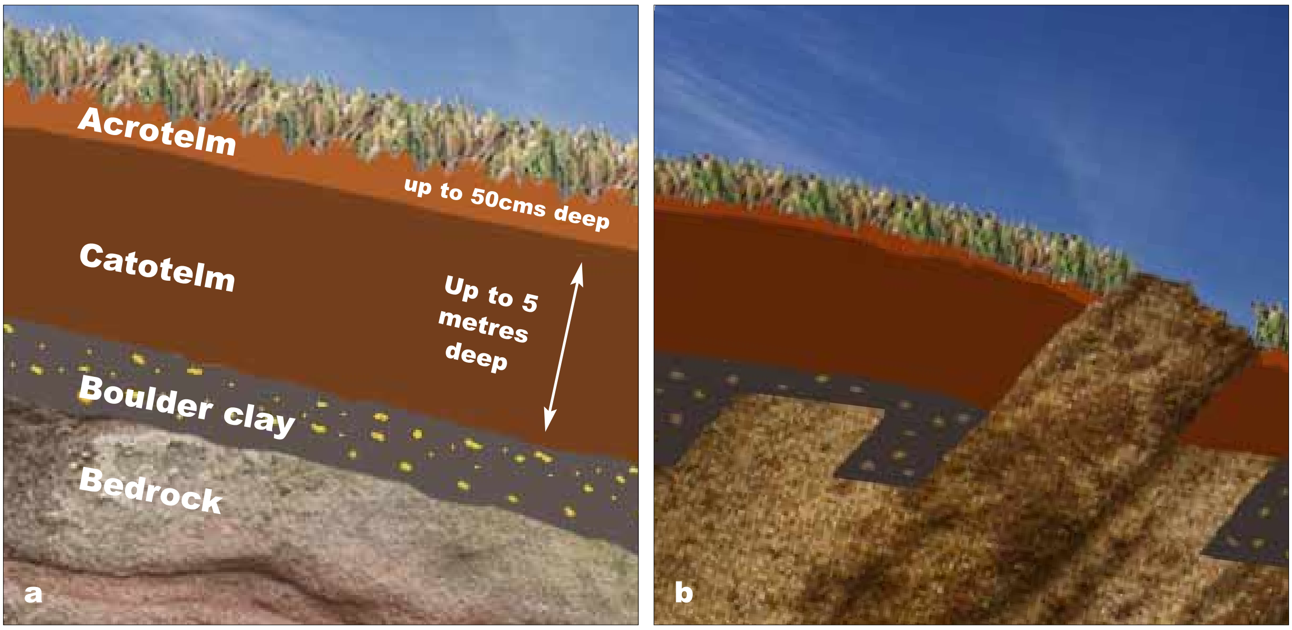
Sandwiched above underlying impermeable bedrock or mineral soil but below the living vegetation on the surface, a bog consists of two distinct parts. Immediately over the bedrock lies a structureless accumulation of partially decayed organic remains which has built up typically over millennia of slow, anaerobic decay. Called the catotelm, this layer is a spongy material which typically contains over 97 per cent water. Although rarely featuring vertical fault-lines, bogs do have horizontal bedding planes that reflect, for example, the presence of bog pools at various stages in their life. This is important when identifying weak horizontal layers on which peat might slide.

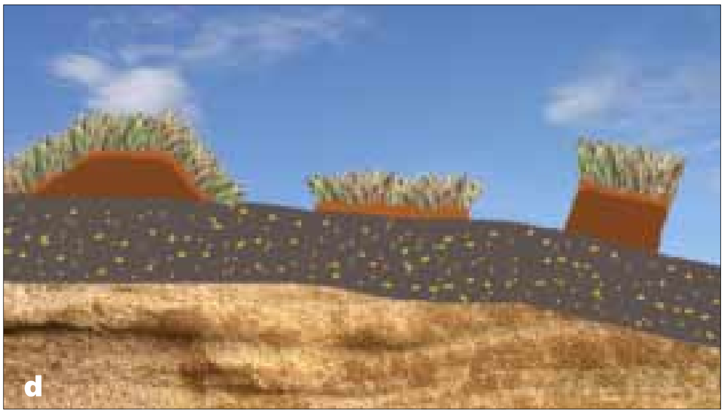
Although water is constantly being lost from the catotelm through gravity-driven seepage and replenished by seepage from the acrotelm, this is a slow process. Undisturbed, the catotelm has substantial resistance to stress although, normally colloidal in character, it can become thixotropic if disturbed.[2]

On top of the catotelm lies the zone into which plant roots penetrate. This upper layer or *acrotelm* is made

1 The Heather Trust, *Annual Report 2005*, www.heathertrust.co.uk.

2 *Thixotropic* describes a gel-like material at rest which is fluid when agitated. It simultaneously possesses high shear strength and low dynamic strength.





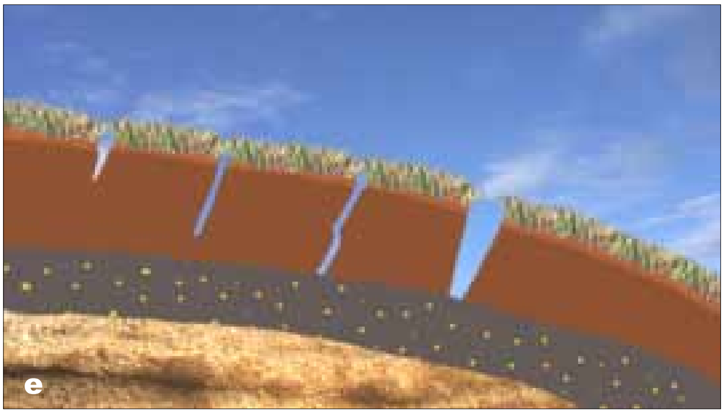


Figure 3: a peat bog comprises a top layer of vegetation growing on the *acrotelm*, a layer made up of the aerial parts of living plants (mosses, sedges, grasses and shrubs), leaf and stem litter, fallen seeds, root material and partially-decayed but still-structured peat. It is typically up to half a metre deep.

Below that is the *catotelm*, a spongy material which usually contains over 97 per cent water, rarely features fault-lines or bedding planes and is usually at least one and often several metres deep.

a: Peat forming on a layer of impermeable boulder clay lying, in turn, on the bedrock.

b: Here, it is forming directly on the bedrock which is sometimes shattered and at others intact.

c: Peat will oxidise and erode once the acrotelm is broken. This produces hagging and, eventually, all the peat disappears.

d: The middle piece of intact acrotelm has come to rest on the mineral substrate and active peat formation will recommence.

e: Peat may shrink and crack in dry weather, particularly if it is hagged or mechanically damaged. This allows the ingress of water to bedrock and can lead to a slide on slopes as gentle as 3°.

up of the aerial parts of living plants (mosses, sedges, grasses and shrubs), leaf and stem litter, fallen seeds (the 'seed bank'), root material and partially-decayed but still-structured peat. It is where almost all the invertebrates which inhabit bogs are to be found. It is more fibrous in character and hence more porous.

Its depth varies according to the characteristics of the site and its past management by man but it is typically between 10 and 30 cm. It is a critical part of the bog as it has the ability to sop up precipitation quickly and release it slowly. As its water content declines once rain and snow-melt has stopped, so its ability to hold on to what remains within it increases. An acrotelm in good condition has a notable capacity to slow down run-off, reduce erosion and maintain stream and river levels further down-stream. It also maintains the catotelm in a nigh-saturated condition except under circumstances of prolonged drought.

The acrotelm is much more variable in character than the catotelm because it is influenced by a variety of factors, some of which are anthropogenic. These include slope, altitude, exposure, soil and rainfall as well as the presence of wild or domestic animals and the husbandry systems adopted over the years. All these lead to pronounced variability in its stability and in the productivity of the plants growing on it.

The relationship between the acrotelm and the catotelm is crucial to understanding the behaviour of a bog. The acrotelm can be pictured as a bedspread tucked into a mattress on all sides and which keeps in place a mixture of sheets, pillows and blankets: it holds the catotelm together. A bog covered by a vigorous and undamaged acrotelm is most unlikely to slip or burst unless interfered with. However, once disturbed or damaged, peat bogs can become intrinsically unstable and large-scale movement can be initiated easily.[3]

If it dries out, the body of a bog shrinks and cracks, leading to fissures. These can be deep and may even penetrate to the bed-rock. Once the moisture-content of this normally structureless peat declines beyond a certain level, it is impossible to re-hydrate it. That is why pieces of fuel-peat which have been properly cured stay in a hard, shrunken coal-like state even when immersed in water for long periods.

The irreversible nature of the relationship between peat and water has long-term implications for any construction activity on peatlands. When the acrotelm is degraded by poor standards of grazing control, by fire or is otherwise damaged (see below), it tends to tear along fault-lines and cracks in the catotelm.

Harvesting peat

Peat depths frequently exceed five metres where slope conditions are favourable. In the West of Ireland, peat areas are extensive, flat and easily worked and peat has been harvested for decades by industrial processes as a fuel for power production.[4] Another, locally significant, pressure on peat bogs in Scotland is its harvesting for use in the whisky industry for drying and flavouring germinated grain. Perhaps the most controversial commerical use of peat has been by the horticulture industry.

In many parishes throughout Scotland and north England, it has long been dug for fuel by indigenous people as a routine task in early summer. The custom persists but on a much reduced scale compared to even 50 years ago.

Afforestation

From the 1960s to 1988, many areas of peat-dominated ground in both lowland and upland areas in Britain were taken out of use for extensive low-intensity agriculture and planted with exotic conifers. Notorious cases were associated with public figures reducing tax liabilities by pre-tax 'investing' in planting, particularly in the Flow country in east Sutherland and Caithness – a *cause célèbre* which led to changes in fiscal regulations.

Many thousands of hectares were ploughed and planted for the establishment of trees with little likelihood of their ever providing a commercial yield. Many of these areas are now being abandoned and there is ongoing debate about how to re-habilitate them, centring in part on their suitability as wind-power sites.

The forestry practices to which they were subjected seriously damaged the acrotelm in two ways. First, at the time of planting, a bog was ploughed at two metre intervals using a giant single-furrow plough pulled by

3 Lindsay and Bragg point out that without an understanding of peat and its particular properties it is a matter of surprise that peat bogs stick to hillsides.

4 Despite campaigns by environmentalists, ESB commissioned two peat-fired power stations in 2005 – a 100MW plant at Lanesborough, Co Longford, burning 750,000 tonnes of peat per year, and a 150MW plant at Shannonbridge, Co Offaly, which consumes 1.25 million tonnes. They replaced older plant.

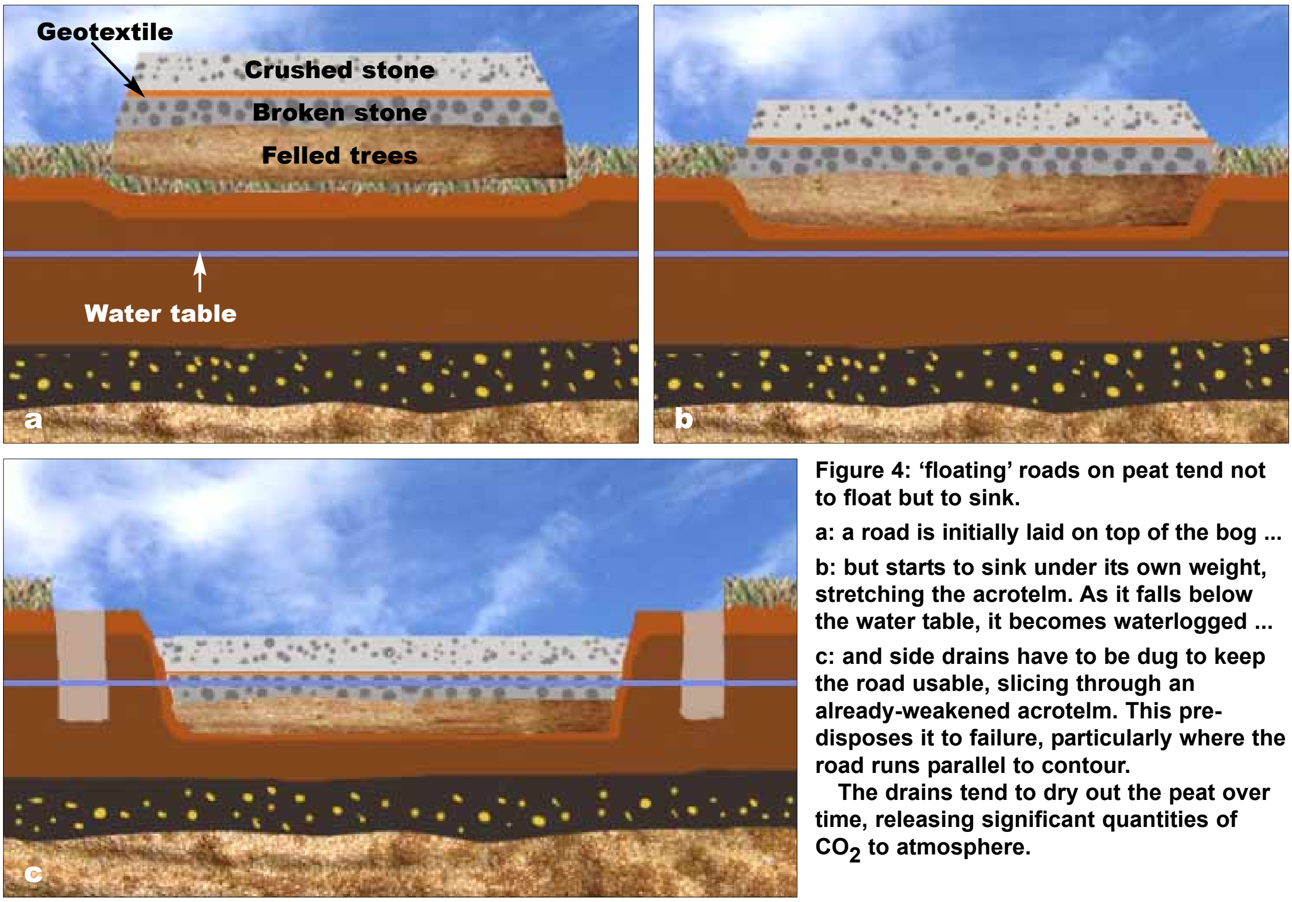


Figure 4: 'floating' roads on peat tend not to float but to sink.

a: a road is initially laid on top of the bog ...

b: but starts to sink under its own weight, stretching the acrotelm. As it falls below the water table, it becomes waterlogged ...

c: and side drains have to be dug to keep the road usable, slicing through an already-weakened acrotelm. This pre-disposes it to failure, particularly where the road runs parallel to contour.

The drains tend to dry out the peat over time, releasing significant quantities of CO_2 to atmosphere.

a crawler tractor producing an inverted ridge of acrotelm lying on top of the undisturbed surface alongside. The furrow was normally at least 50cm deep and usually penetrated into the catotelm. When tree seedlings were planted on the top of the furrow, this provided two lots of acrotelm-based nutrients within easy reach of the tree roots as well as a drier root-run for the tree and a local reduction in the water-table. It was also normal practice to cross-drain using a bucket to excavate trenches substantially deeper than the plough lines.

However, the main impact of afforestation is not from ploughing but from the loss of water caused by evapo-transpiration from the tree crop and interception by the canopy. This is primarily why peat beneath forestry shrinks and cracks.

The effect is to degrade the bog, dry it up, increase the oxidation rate of the peat and allow fissuring to extend deep into the catotelm in dry spells. Such fragmented and dissected bogs are often so badly damaged that they are particularly likely to slip.

Anthropogenic degradation

The main natural causative factor of bog erosion is probably fire. Raised bog and low-level blanket bog are likely to burn naturally about once every 300 to 400 years – a long enough time for the habitat to recover although recovery time increases significantly with altitude: a bad fire even after an interval of 200 years at higher alititudes is severe enough to lead to serious breakdown of the mire surface.

No bogland in Britain is truly natural. All have been burned by man and grazed by wild and domestic animals for centuries and many show unmistakable evidence of damage from these causes. In others, particularly in the Pennine Chain, industrial pollution in the 19th-century wiped out the main building-block of peat bog and its means of repair when damaged – the Sphagnum mosses. The problems have been exacerbated by increases in hill sheep numbers and by summer fires caused by the public.

The practice of muirburn – the rejuvenation of heather moor by grazing and grouse shooting interests which takes place under statute between October and April – can, if poorly carried out, severely damage the acrotelm. If it is done too frequently or if the fires are too hot, the roots, litter and decaying matter under the plant canopy can be destroyed and, in extreme cases, the catotelm may be exposed.

Acrotelm damage can also be due to trampling by humans. Where it crosses deep peat, the Pennine Way is often a morass 50 metres wide. In the Peak District National Park, peat has eroded from over 40 sq km of moorland out of the just over 500 sq km which make up the park area.[5] Once the acrotelm disappeared, the underlying material was (and is still being) eroded by frost heave, wind, oxidation, water and trampling by humans and domestic sheep. The result is extensive *hagging*. The bog becomes so fragmented that the combination of acro- and catotelm contributes little to the temporary absorption of water and its subsequent slow release. Peaks and troughs of water-flows are accentuated, further increasing the rates of run-off and sheet and gully erosion.[6]

This fragmentation of otherwise intact peat lenses and the formation of peat hags is widespread throughout highland Scotland and can be readily observed during any flight over hill country. In many montane places, the causal agent has been not pollution but trampling by sheep and deer. Natural phenomena such as wind, excessive short-term rainfall and frost-heave are also major contributors to the process.

In these heavily hagged places, peat movement is chronic rather than acute, with peat being lost by a process of slow attrition that is, in practice, almost unstoppable. In some places, it is occurring alongside the formation of fresh peat, which suggests that the process may be more 'natural' than many commentators accept.

The potential for failure

Even where a blanket bog is relatively intact (and 'relative' is here an indefinite term), it is possible for apparently superficial damage to an otherwise intact acrotelm grossly to upset its hydrology and lead to a slide. Contributory factors are the slope, the aspect, the rainfall (both exceptional and annual background levels) and historical and current land use, particularly the numbers of animals living on or trafficing across the site.

Also critical is the angle to contour of any disturbance of the acrotelm, such as the gross manipulation or alteration of drainage channels or the digging of new ones or the construction of roads, either 'floating' or where the peat is dug out and imported minerals are laid directly on the underlying bedrock.

The failure mechanism with floating roads is straightforward: loading the acrotelm with several tonnes per running metre of construction material compresses it, causes it to sink and deforms the catotelm underneath. Eventually, the acrotelm is stretched beyond its tensile strength and elastic limit. It tears. If the road is running along a contour, this weakness will predispose downside peat to slip because the cohesion of the cover over the catotelm provided by the overlying acrotelm has been compromised.

As a floating road is usually about five metres wide, loading on the acrotelm is over three tonnes per running metre, equivalent to a ground pressure of over 0.8 kg/cm^2. The regular passage of vehicles with a loading as low as 0.3 kg/cm^2 can cause acrotelm to fail (an average human being walking on blanket bog exerts 1.5 to 1.8 kg/cm^2). In contrast, the cranes required for turbine construction weigh up to 120 tonnes unladen and load the roads by anything up to 6 kg/cm^2.

Conclusion

An appreciation of the characteristics of peat land, particularly once it is disturbed, is rarely found in EIAs: contractors and their advisors generally demonstrate a low level of knowledge of the dynamics of peat.

Peatland habitats support a variety of rare and endangered animals and plants. They are also important sinks where carbon can be sequestered. The UK has an international obligation to conserve them. Wind farms are proposed for peat-dominated sites all over the country, many of them on the ridges of hills covered by blanket bog of considerable depth. Without exception, they will have been affected by agricultural and/or forestry activities over many decades and the blanket bog is often in a damaged and potentially unstable state.

These sites and the materials that comprise them do not respond well to practices which may well be suitable for mineral soils. They behave quite differently and in many cases contractors have no first-hand experience of the problems they are likely to encounter.

5 See www.moorsforthefuture.org.uk on the project to regenerate the Peak District and good pictures of the problems.

6 *Sheet erosion* is where material is removed by wind and/or water over a wide area; *gully erosion* is where water cuts an ever deepening track in the land surface.

Annexe 3 – the Cefn Croes case

While it is legitimate to question to what extent Derrybrien provides realistic pointers to comparable sites elsewhere, the answer has to be found in the record. 'Peat stability assessments' submitted in support of Scottish proposals have implied that the bogslide was an isolated incident on a development beset by inappropriate construction techniques (a problem since happily resolved) and one Scottish environmental body is on record as reporting that its scale has been 'exaggerated'. However, these claims are based at best on a partial reading of the literature.

There are few reports in the public domain of construction or post-construction monitoring of recent developments but a notable exception is the 39-turbine, 59 MW development at Cefn Croes, near Aberystwyth, sited partly on peat. Local environmental campaigners have kept a photographic record since construction began.

As this sample of their work suggests, many of the issues encountered in Ireland arose also in Wales. Earlier this year, the Environment Agency instigated legal proceedings against the site's contractor following a pollution incident in 2004 although it failed to prove culpability.

Plate 13a, above, is a view of the project as it neared completion in August 2004 and 13b (below) shows a waterlogged base excavation. Plate 14 suggests the extent of the drainage cut on the site and plate 15 shows steps taken to prevent excessive drainage and some of the measures adopted to prevent downstream siltation.

Plate 14a: the excavation for base 28. Even if this is back-filled with ‘borrowed’ mineral, the adjacent peat will dry out and oxidise over time. The drain runs into a waterway visible in the top left of the picture.
b: the view down the channel draining turbine 25.

c: the drainage channel for turbine 25;

d: drainage by the access track between turbines 25 and 26;

e: drainage north-east of turbine 25, on the north-eastern edge of the site (August 2004).

Plate 15a, b: a series of 12 ‘lagoons’ has been dug near turbines 25 to 30, apparently to reduce the drainage of peat on the site. The dams between them are reportedly made with railway sleepers but the methodology is unclear. (August 2005). The pictures show three of them.

c-e: straw bales were laid to prevent downstreram pollution (August 2004).

f: a ‘floating’ road during construction (August 2004).

A glossary of technical terms

Alternative Energy Requirement – Ireland's AER was introduced in 1995 to facilitate renewable energy development. Modelled on the UK's Non Fossil Fuel Obligation, its aims are to support long-term investment, diversify sources and reduce damage caused by energy production. (See www.sei.ie)

Competent authority – the body that decides on an application for development consent. It need not be an environmental authority: for Scottish wind-power applications over 50MW, it is the Enterprise, Transport and Lifelong Learning Department.

Environmental Statement – submitted by developers to competent authorities. The environmental impact assessment of public and private projects falls under EIA Directive 85/337/EEC and amendments.

European Union Directives – the European Union adopts legislation in the form of Directives and Regulations which member states must implement. Regulations directly implement EU policy in member states without the need for legislation.

Salami slicing – a semi-official term for the practice of submitting multiple planning applications for an essentially larger unitary project with either the intention or the result of avoiding environmental impact evaluation. Applications are considered piecemeal, with little or no regard to the cumulative effect of the 'phases' taken together.

Plate 16: Three substantive reports addressed the Derrybrien incident. Left: AGEC's report to Hibernian Wind Power was limited to the direct causes of the slide and BMA GeoServices' report to Galway County Council had only a slightly wider brief (centre). Richard Lindsay & Dr Olivia Bragg's report (right), for a local stakeholders cooperative, had a broad and explicitly environmental remit. Only the first informs assessments of comparable Scottish sites and these are thus, inevitably, partial.

Acrotelm – the top layer of a peat bog. Made up of living plants and leaf litter, it is spongy and fibrous in texture, highly porous and absorbent.

Aerobic – in this context, plant decay that depends on the availability of oxygen; q.v. **Anaerobic** – a process requiring the absence of oxygen.

Bedding plane – a bedding plane marks the termination of one deposit and the beginning of a different one. The catotelm is often, but not always, homogeneous.

Bog burst – peat in slurry form cascades from a break in the bog surface; q.v. **Peat slide** – a failure within the peat; detached rafts of vegetation are carried by a mass of liquid peat and **Bog slide** – an intermediate type.

Catotelm – decayed and humified material beneath the acrotelm which builds up over years to form peat.

Colloid – minute particles of organic material (10^{-7} to 10^{-9} metre) suspended in water: a colloid's properties are between those of a solution and a fine suspension.

Eutrophication – a process whereby pollution causes water to become over-rich in nutrients; algae and bacteria grow rapidly and deplete the oxygen supply.

Mor – acidic humus formed under anaerobic conditions; q.v. **mull**, a non-acidic humus that forms in well-drained and aereated soils.

Soil capacity – the amount of water a soil can hold before run-off commences.

Thixotropic – a term for fluids or gels whose viscosity is reduced when stress is applied (e.g. when 'thixotropic' paints are stirred).

Transpiration – the loss of water as vapour especially through the stomata of a plant's leaves.