IUCN UK Committee Peatland Programme
*Briefing Note N°**9***

Weathering, Erosion and Mass Movement of Blanket Bog

IUCN National Committee United Kingdom
Peatland Programme

The erosion problem

Weathering

Erosion

Vegetation can increase weathering but decrease erosion

Peatlands reduce erosion of the underlying sub-soil

Water-filled peat accumulates on summits and slopes

Little or no evidence of

Weathering is the process of breaking down solid material such as rock into smaller particles, through agents such as heating, freezing and chemical attack. These particles can then be transported away through the process of ***erosion*** by agents such as water and wind. **Vegetation to some extent insulates bare rock and skeletal soils** from these processes by **providing a protective layer.** The action of plant roots can, however, result in biologically-driven weathering when roots invade cracks and split rock, or release chemicals which transform and break down the parent rock or soil. At the same time, the root systems and fallen leaf litter add organic matter to the soil, increasing its complexity and bulk volume.

Consequently while weathering may continue beneath a vegetation cover, **soils tend to become stabilised and thus erosion tends to diminish where there is a blanketing layer of vegetation. Nowhere is this more so than in peatlands, particularly blanket mire landscapes which in the UK tend to occur in upland regions where the agents of weathering and erosion such as rain, frost, wind and slope are particularly marked**, and where mineral soils often consist of unconsolidated glacial till ('boulder clay'). Across this unpromising landscape the formation and growth of peat results not merely in stabilisation of the mineral ground surface, but **results in soil (peat) accumulation to the extent that many, if not most, of the factors associated with weathering and erosion become dissipated or smothered by the accumulating mass of peat** and its living, peat-forming surface vegetation.

Blanket peat development is all the more remarkable, therefore, **given that undisturbed peat generally has a water content by weight of between 90% to 98% - in other words, far less solids than milk - yet it is draped across slopes of 35˚ or more and some of the deepest, wettest peats, sometimes displaying extensive mazes of large bog pools, dominate broad watershed hill summits** (see ***Definitions Briefing Note 1***). In the Falklands, which are another location of extensive blanket mire, it is said: "The water all sits at the top of the hills."

Such an unlikely set of conditions would appear to be a recipe for long-term disaster. Indeed the fact that blanket mire erosion is so widespread in the UK originally led to the idea that collapse and erosion of these systems was a natural process and therefore unavoidable. **However, little or no convincing evidence has been advanced**

natural instability; strong link to human impacts

to underpin this belief. In contrast, a body of evidence has since accumulated which links blanket bog weathering, erosion and instability to **a variety of human-induced impacts including fire damage, atmospheric pollution, drainage, track construction, trampling and overgrazing, and even to Neolithic tree-removal from hill slopes on the margins of blanket bog systems**.

Erosion starts with loss of peat-forming vegetation

The development of erosional features begins with loss of the living, peat-forming vegetation and thus loss of a functioning acrotelm (see ***Biodiversity Briefing Note 2***), thereby **exposing the unprotected catotelm peat to the agents of weathering**. Drainage, burning, atmospheric pollution, peat cutting, or trampling and 'rubbing' (caused by sheep or deer sheltering against a weathered peat face) have generally been the primary causes of such acrotelm loss and loosening of the exposed peat surface.

Erosion is associated with many effects of drainage because gullies resemble drains

Some erosion may be caused by Neolithic tree removal

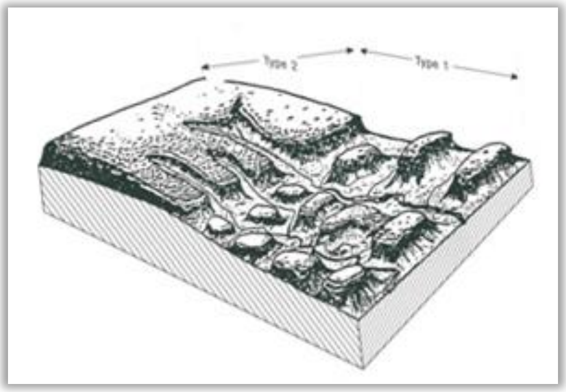
Agents of erosion then remove this loosened peat, leading to formation of large-scale erosion complexes. This may occur through breakdown of an established natural surface pattern with emptying and inter-connection of pools and hollows into a drainage network, which then leads to drying, subsidence and formation of major drainage channels which have much the same impact as artificial drains do on a peat bog (see ***Drainage Briefing Note 3***). Alternatively, breakdown may result from upstream progression of an artificially rejuvenated stream gully (typically straightened and deepened into a drain) which cuts into the peat body from the margins, again ultimately leading to breakdown of the main bog surface and the drainage effects referred to above. It has been suggested that such headward stream erosion may have occurred when scattered tree cover on peat-covered slopes of the Pennines was removed in Neolithic times, this loss of tree cover causing a substantial increase in stream erosion

It must be stressed that erosion is also driven by drying processes which occur at the micro-scale around the margins of bare peat. This leads to extension and expansion of exposed areas of peat and ultimately gives rise to development of erosion gully systems.

Natural bog pattern lies <u>across</u> line of water seepage; erosion is aligned <u>with</u> direction of water flow

'Jigsaw' erosion pattern where slope is low

Linear gully erosion on steeper slopes



While the **characteristic feature of natural peatland patterns is that the pattern of ridges, hollows and pools lies *across* the direction of water seepage**, the distinctive feature of **eroding systems is that the gullies and haggs are oriented in the *same direction* as the general pattern of water flow**. This is most readily observed from an aerial image using, for example, Google Earth or 'Satellite' view in Google Maps. Summit erosion formed across broad watershed plateaux or on the gentle slopes of valleyside mires (see ***Definitions Briefing Note 1***) tends to result in an interconnected 'jigsaw-like' patterns of gullies and haggs (Type 1 erosion). As slopes become steeper, the typical pattern becomes that of parallel gullies running straight downslope (Type 2 erosion).

Lowland bogs have no gully erosion

It is interesting to note that, despite extensive human impact, lowland raised bogs in the UK show no signs of the severe **gully erosion** found in blanket mire landscapes. At most, they display a degree of **micro-erosion** in which the surface forms a shallow drainage network between small tussocks.

Annual loss of carbon from blanket bog erosion equivalent to annual emissions from 700,000 households

Blanket bog, on the other hand, represents the **largest accumulated terrestrial carbon store** in the UK, but, instead of capturing more carbon, it is now **actively losing carbon at the rate of around 3.7 million tonnes of CO_2e each year, which is roughly equivalent to the annual emissions from 700,000 households**.

The main reason for this is that the majority of UK blanket bogs are degraded and many have suffered severe erosion. **Only about 18% can be described as being in "near-natural" condition. Over 50% do not have peat forming vegetation and the remainder are so damaged that they are actively weathering, eroding, and in some cases have even suffered catastrophic collapse**.

Catotelm losses of 3 cm/yr

Single storm events important

Weathering and erosion together can remove peat from the catotelm at rates of **more than 3 cm per year, so a peat depth of 3 m can be lost in just 100 years** if such rates are maintained. In fact losses are more closely linked to individual weather events. A **single heavy storm after a long dry spell can remove more material in a few hours than had been lost over the whole course of a year**.

Remarkably little sub-soil exposed

Severely eroding blanket bog **can produce over 30 tonnes of CO_2-equivalents per hectare per year**. This finds its way off-site both via direct loss to the atmosphere through oxidation of the peat and as a result of erosion by wind and water. **Eroding blanket bog systems are associated with high levels of particulate (POC) and dissolved organic carbon (DOC)** which can significantly reduce water quality and substantially increase water-treatment costs, particularly in reducing levels of organic matter in order to prevent production of trihalomethanes (see ***Drainage Briefing Note 3***). Downstream fishery interests may also be affected by increased peat sediment, as may the pattern of downstream flooding.

Regeneration and restoration

Complete loss of the peat mass is the last stage in the general degradation of a blanket bog ecosystem. However, given the widespread nature of blanket mire erosion and in some cases its apparent ancient origins, **it is surprising how little ground of the uplands has been so completely denuded in this way**. Individual gullies may reveal exposed glacial till or bare rock, but wholesale exposure of the underlying mineral soil is extremely rare.

Natural regeneration of erosion systems

Indeed **across extensive areas of eroded blanket bog in the UK there is clear evidence of erosion gullies blocking up and re-wetting naturally**, with *Sphagnum* bog moss choking and ponding the gullies while the characteristic vegetation of erosion haggs - namely heather and/or *Racomitrium* moss hummocks - is gradually being overwhelmed by a *Sphagnum*-rich bog vegetation. Indeed, even the most severely eroded areas have demonstrated **the**

Active systems can

be restored within 20-30 years	**capacity for such systems to re-establish and become vigorously peat forming within 20-30 years, particularly if natural recovery is assisted by restoration management** designed to reduce exposure of bare peat surfaces and slow water movement through the erosion system.
Areas at risk	Blanket bog erosion is a **consequence of stressors on blanket bog** condition that work in concert to bring about a physical change in the bog ecosystem. Consequently areas most at risk are those which are most subject to such stresses. The principal changes caused by these various forms of stress is disruption of the fibrous living acrotelm layer and exposure of bare peat surfaces.
Major stressors	The major forms of stress are **burning, trampling and grazing, artificial drainage and, in the past, atmospheric pollution**. These generally act **in the short-term by directly creating bare peat surfaces and indirectly through longer-term changes in the hydrology of the system** (see ***Drainage Briefing Note 3***) **and/or changes in bog vegetation** (*e.g.* loss of keystone peat-forming *Sphagnum* spp). Specific stressors may be high-intensity fire events, artificial drainage, or heavy trampling/poaching of surfaces by domestic and/or wild herbivores or ATVs.
Pollution	**Historically some areas such as the Pennines have experienced high levels of atmospheric pollution which directly killed the keystone moss species**. This is no longer considered to be a major cause of stress because atmospheric pollution levels have diminished substantially in recent years. Aerial pollution may nevertheless continue to result in low-level chronic stress, particularly in terms of ongoing nitrogen inputs which favour vascular plant species that are stronger competitors than the keystone *Sphagnum* bog moss. In sub-optimal conditions (such as where there is ongoing drainage, or burning, for example) this may constrain somewhat the re-establishment of *Sphagnum* cover.
Shedding Vs Receiving sites	Erosion risk may also be determined by the topographic and hydrological context of the bog. Blanket bog systems typically lie on ridge crests or on significant hill slopes. They are therefore **intrinsically more susceptible to the forces of water, wind and ice when the protective acrotelm layer is lost**. Thus blanket bogs which have been frequently burned, have been drained, and which have a high grazing and trampling pressure, tend to experience the most severe erosion because they have lost the protective peat-forming acrotelm layer. Perhaps more significantly given recent developments, **unprotected catotelm peat tends to dry and crack during dry weather, providing routes for subsequent rainstorms to feed storm-water down to the interface between the overlying mass of peat and the underlying glacial till**.
Drying and cracking of catotelm directs storm water to peat-mineral interface	
Several major peatslides in recent years	This is likely to have been the **cause of several major recent peatslides** (technically, 'mass movement following slope failure'), particularly where the surface mat of fibrous *Sphagnum* and cotton-grass roots has additionally been severed by the digging of a drain or the cutting of a peat- bank - sometimes many decades earlier.
Track construction may cause instability	Track construction across blanket peat, especially if side-drains are dug severing the fibrous surface mat, provides yet further potential for instability and mass movement resulting from the extra loading on this essentially liquid soil, but may also trigger or exacerbate more typical peatland erosion in the long term (see ***Tracks Briefing Note 11***).

Other benefits from addressing the issue	Reduced levels of burning and grazing, and blocking of artificial drainage systems and erosion gullies, lead to recovery of bog ecosystem functions including: • re-development of bog-species associations; • major reductions in GHG emissions and increased carbon capture and storage; • improvements in water quality (particularly reduction of organic-matter content and reduced likelihood of trihalomethane production; • depending on catchment context, possible flood mitigation; • reduced danger of mass movement/peatslides.
Gaps in Knowledge	Blanket bog erosion has been something of an enigma for many years because it is so widespread and because it has so often in the past been described as a natural end-point of blanket bog development. Establishing clear and definitive links between various forms of human impact and the pattern of blanket bog erosion in the UK is likely to shed light on the way in which such systems should be managed in the future. The Peatland Compendium provides an extensive information resource about the restoration of eroded blanket bog, based on a large number of restoration projects undertaken across the UK. See: http://www.peatlands.org.uk/ A review of published scientific evidence concerning the restoration of degraded blanket bog has also been undertaken recently by Natural England. See: http://publications.naturalengland.org.uk/publication/5724822 This provides a summary of published evidence and identifies certain key gaps in knowledge concerning restoration of eroded bog, the most significant being the timescales required for the various restoration methods to achieve blanket bog in good condition.
Practical Actions	Erosion is almost certainly not predominantly a natural phenomenon on UK blanket bogs. The stimulus for erosion can thus be reversed by removing the stressors. Recovery back to a near-natural blanket bog ecosystem state will inevitably take longer from an eroded state than from a less impacted state where some *Sphagnum* remains in the vegetation. However, it is practical to restore even severely-eroded bog ecosystems. The main practical actions are: • Block all evident artificial drainage channels. • If currently present, stop burning altogether. • Remove, as far as is practicable, domestic and large wild herbivores for a period of up to 30 years and *review* at that time. Continuing to graze these systems slows potential vegetation recovery because of ongoing physical damage to exposed bare peat surfaces through trampling and rubbing (because blanket bog landscapes tend to be very open, the only available shelter for animals is often within the eroding areas). • If necessary, use mulching and strategic gully blocking to increase the rate of vegetation recolonisation. • If required, consider other forms of vegetation re-establishment including placement of *Sphagnum* propagules.
More Information	Underpinning scientific report: http://www.rspb.org.uk/Images/Peatbogs_and_carbon_tcm9-255200.pdf (low resolution)

	http://www.uel.ac.uk/erg/PeatandCarbonReport.htm (high resolution : downloadable in sections) IUCN UK Peatland Programme: http://www.iucn-uk-peatlandprogramme.org/ Natural England Uplands Evidence Review: http://www.naturalengland.org.uk/ourwork/uplands/uplandsevidencereviewfeature.aspx Scottish Natural Heritage Report on peat definitions: http://www.snh.org.uk/pdfs/publications/commissioned_reports/701.pdf Peatland Action: http://www.snh.gov.uk/climate-change/what-snh-is-doing/peatland-action/ *This briefing note is part of a series aimed at policy makers, practitioners and academics to help explain the ecological processes that underpin peatland function. Understanding the ecology of peatlands is essential when investigating the impacts of human activity on peatlands, interpreting research findings and planning the recovery of damaged peatlands.* *These briefs have been produced following a major process of review and comment building on an original document: Lindsay, R. 2010 'Peatbogs and Carbon: a Critical Synthesis' University of East London. published by RSPB, Sandy. http://www.rspb.org.uk/Images/Peatbogs_and_carbon_tcm9-255200.pdf, this report also being available at high resolution and in sections from: http://www.uel.ac.uk/erg/PeatandCarbonReport.htm* *The full set of briefs can be downloaded from:www.iucn-uk-peatlandprogramme.org.uk* *The International Union for the Conservation of Nature (IUCN) is a global organisation, providing an influential and authoritative voice for nature conservation. The IUCN UK Peatland Programme promotes peatland restoration in the UK and advocates the multiple benefits of peatlands through partnerships, strong science, sound policy and effective practice.* *We are grateful to Scottish Natural Heritage, Natural England, Natural Resources Wales, the Forestry Commission RSPB Scotland and the Peter de Haan Charitable Trust for funding support.*
Authors ***Date***	**Richard Lindsay, Richard Birnie, Jack Clough** **Version Date: 5th November 2014** UEL University of East London