IUCN National Committee United Kingdom

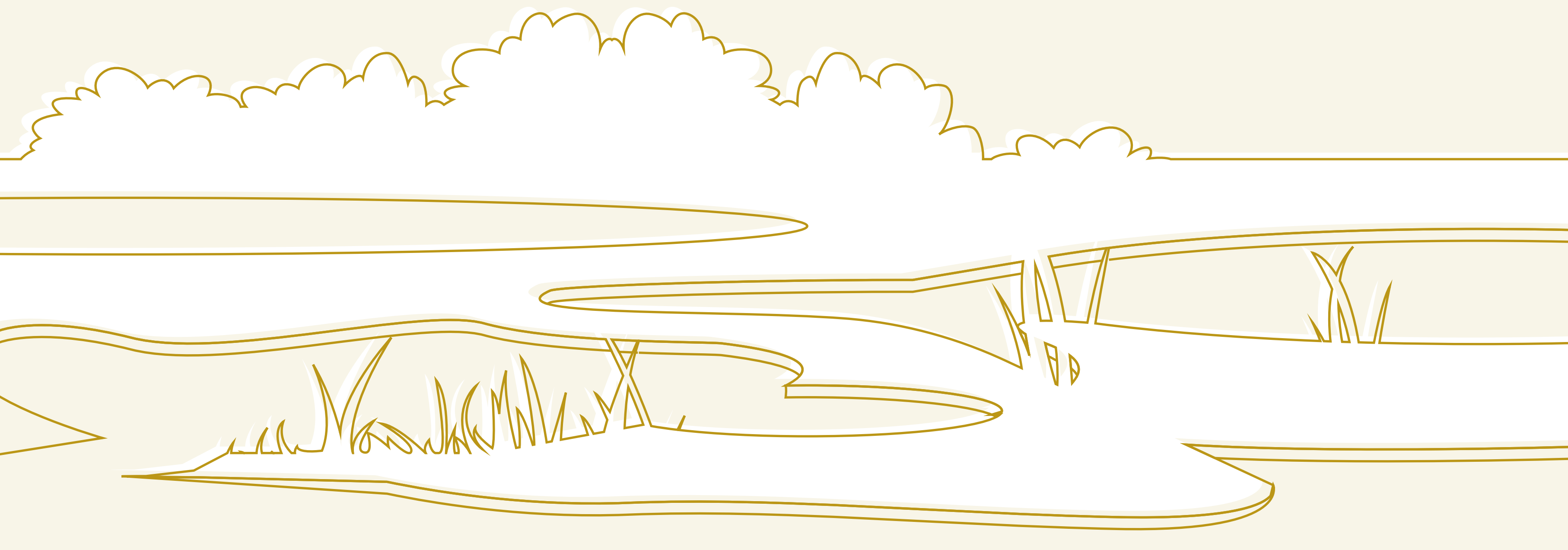
Peatland Programme

Networks of change: Tracks and roads on peatlands

This briefing is a technical companion to Briefing Note no.12 'Tracks across peatlands', which remains relevant and provides background context to this briefing. This document discusses findings from research published since the previous briefing. Focusing on upland peatlands, where linear developments are most prevalent, it highlights evidence gaps, and includes points for policymakers.

Summary of key points

1. The density of the road and track network on nominally protected upland peat sites of the UK is ~10 times that of the wider UK road network.
2. Roads and tracks can have wide ranging impacts over both the long and short term when they are created. They can cause changes to both the ecological and physical properties of the peat. Hydrologically they can create isolated units if they become compacted or are excavated, by affecting lateral flow of water through the peat soil. They can also act to channel water over the smoother surface of the track, increasing the likelihood of erosion on track edges or downslope areas of soil where water drains from the constructed surface.
3. Unsurfaced tracks, whether created intentionally or as ad hoc access routes with even minimal usage (such as footpaths), can persist for extended timeframes in the landscape. The ruts from single passes made by off-road vehicles such as dirt bikes or quad bikes can also last for significant timeframes and initiate changes to the patterns of water flow across the land surface.
4. Based on research studies which have followed the removal of temporary tracks from peatlands, extensive bare areas are left if restoration is not undertaken. This can leave the peat surface vulnerable to a variety of erosion processes including wind, rain splash, overland flow, and needle ice formation. Once eroded, the peat may be washed away and lost to the wider catchment, leading to increased dissolved and particulate organic carbon loads in rivers and streams.
5. Vegetation communities associated with track edges are often different to those of the surrounding undisturbed peatland areas; studies in North America have found these to be persistent over multi-decadal timeframes. Where vehicles have carried seeds from non-peatland habitats, there is a risk that these may become established along the disturbed track edges and spread to the wider habitat.



Common types of tracks

Ad hoc, unsurfaced tracks are common due to human and animal presence in peatland landscapes. These may be caused by animal or human walking, or by the result of vehicle usage. Where present, they may form dense networks which can be seen readily in aerial imagery (figure 1). This pattern is seen globally: in Alaska, unsurfaced tracks created for seismic exploration represent the largest footprint of human disturbance of all activities combined on the tundra [1].

Figure 1. Aerial image showing a network of tracks on a blanket peatland site in England's North Pennines: a. ad hoc unsurfaced tracks; b. an area where a geogrid track was removed, and c. a geogrid surfaced temporary track. Note also the dense network of linear hill drains (running largely top to bottom of the image) which add to the overall disturbance and degradation of the peatland unit when combined with additional impacts, such as tracks. Credit: Bing Maps.

Some tracks have been created with the view to being temporary, using geogrid surfaces designed to protect the peat beneath by allowing plants underneath to grow through to provide greater structural strength and allowing water to percolate through the track surface. In practice however, plants may not grow through the track due to usage pressure (figure 2). Plastic geogrid is designed to have a short lifespan of approximately five years, after which time it is removed. However, the mesh used for these tracks was originally designed for use as grass reinforcement over mineral soils which have low water contents and significantly higher tensile strengths than peat soils. This means that the tracks are more likely to break, resulting in rut formation in the peat. Once the mesh becomes embedded in the peat, it becomes even more challenging to remove.

Stone surfaced tracks are designed for heavier vehicular usage and are more likely to be a permanent construction with ditching and/or culverting to prevent flooding on the track surface. Wooden tracks are less commonly used but designed to support heavier vehicle uses and can be removed at the end of their lives. Indeed, 'bog mats' – often large wooden pallet type structures which are placed one by one in front of diggers when undertaking peatland restoration on deep peat - are a temporary method of wooden tracking which is used to spread vehicle weight and limit the damage to the vegetation and peat soils. Bog mats are lifted as soon as the digger has passed over that spot and so the impact is considered to be minimal. Permanent stone and wood track types can be a source of nutrient enrichment or cause chemical impacts on naturally acidic, nutrient poor peatlands.

Figure 2. Consented temporary mesh track approximately 6 years post-installation on a deep peat area in England's North Pennines, showing areas of sparse regrowth and pooling. Credit: Jess Fior-Berry.

Contemporary demand for tracks and roads

In the UK, tracks across peatlands serve a variety of purposes. They may be created for the purpose of walking or hiking, or used to facilitate development, forestry, agricultural, sporting or restoration activities. As a result of this, roads and tracks have increased significantly in extent. In Canada for example, seismic lines which are unsurfaced single passage tracks supporting oil exploration are a significant source of disturbance through areas of boreal peatlands.

However, whilst the expansion of road and track networks for these activities has been rapid in many places, research into their potential impacts has lagged. This is in part due to a lack of understanding of the impacts of tracks, and in part due to the time taken to gather and analyse data. Despite many unknowns, roads and tracks have been constructed on many protected peatland sites, in spite of requirements to apply 'precautionary principles'.

What has emerged from research both from the UK and globally to date, is a clear picture of widespread changes to both the ecological and physical properties of peatlands, that are brought about through the creation of both surfaced and unsurfaced tracks and roads.

Research into peatland roads

Since the publication of the first IUCN UK Peatland Programme Briefing Note 'Tracks across peatlands' in 2016, considerably more research evidence is available. This means that researchers are now less reliant on extrapolating potential impacts based on findings from other related areas of peatland research. The caveat to this from a UK and European perspective is that a significant proportion of the current research has been generated from North America and Canada, where boreal and permafrost peatlands dominate. Therefore, care must be taken in extrapolating findings to high rainfall, high altitude UK sites and those which experience freezing only seasonally and even then, not consistently. In tropical woody peatlands, where extensive clearances have taken place for agriculture, there is almost no research into the impact of tracks and roads.

While early research was largely concerned with the engineering properties of peatlands, as the importance of peatlands environmentally became more widely appreciated, a significant uplift in research across a wide range of topics relating to specific impacts has occurred (figure 3).

Ecological effects

Roads and tracks are linear features which create abrupt boundaries between or within habitats, resulting in what is termed in ecology as 'edge effects'. Examples of edge effects include behavioural changes in individuals, or changes in population abundance [3]. There may also be structural changes, or changes to microclimates associated with these delineations [4]. Studies of sites with tracks on peatlands in the UK and Canada have found decreases in bog species compared to reference sites, and increased spread of generalist and invasive species into the surrounding habitat from tracks [5 6 7]. A graduated reduced sward height effect has also been recorded on the edges of temporary tracks, up to 10 metres from the track edge [8].

However, it should not be assumed that an absence of significant changes when infrastructure is initially constructed means there has been no impact, as peatlands can exhibit significant time lags in relation to ecosystem function [9 10 11]. This delayed response was studied on a mountain bog site in Germany where a road impeded water flow, altering the hydrological gradient. This led to a change in vegetation, and ultimately a rapid succession by coniferous trees after a period of drought [12]. Research has found that in some instances where a track has been created, there is a fundamental change to the vegetation community, such that it will not readily return to a composition comparable to undisturbed reference sites [13 14 15].

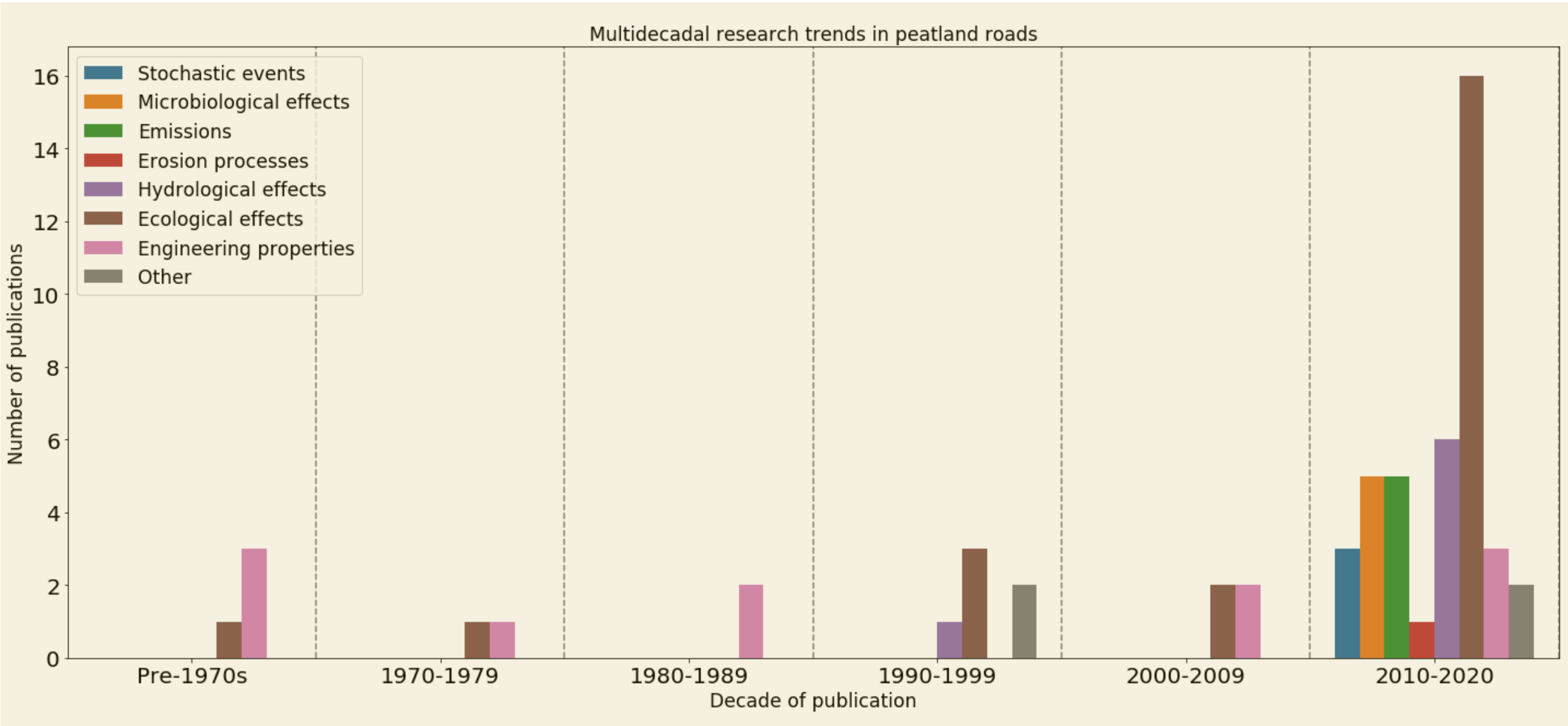


Figure 3. Publication trends in topics concerning the effects of peatland roads (from Williams-Mounsey et al., 2021)[2]

There are also structural impacts associated with tracks, with persistent flattening or simplification of microstructures recorded on both temporary surfaced and unsurfaced tracks on peatlands in the UK and Canada [8 16 17]. Increased bare peat occurrence on temporary tracks is not correlated with usage rates, with occurrence exceeding or comparable between low and high usage rates [6 8].

Figure 4. Tracks can persist on peatlands for long time frames post-abandonment. The mesh surfaced track shown here was abandoned 6 years prior to this image being taken, and both the outline of the track and the ruts from past vehicle usage remain clearly visible. Credit: Jess Fior-Berry.

Physical properties and hydrological functions

In healthy, diplotelmic peatlands with both an active acrotelm and hydrologically stable catotelm, the loss of sediments to rainfall and overland flow events is limited by availability of exposed peat. Conversely, in degraded peatlands which have exposed peat surfaces, weathering processes such as needle ice formation, mud-crack plate formation, rain splash and desiccation provide a continual source of new sediment [18 19].

Where a track is created – surfaced or unsurfaced – there is a risk of erosion from usage, and the creation of ruts can exacerbate these problems by acting as channels for flow. The simplification of the surface structures leads to decreased surface roughness, meaning that overland flow events can occur with increased velocity [20 21]. Geogrid tracks have been found to lead to increased frequency of recorded overland flow events and subsequent sediment run-off [22] compared to undisturbed reference areas. They do not appear, however, to impact the hydrological gradient in the same way as constructed, stone tracks [6].

Tracks have also been found to have a damming effect with North American studies highlighting flooding occurring upslope and drying on the downslope. Culverts can attenuate some of the effects of the tracks, but they may also focus flow leading to, in some instances, incision and even gullying [2].

Figure 5. A consented mesh track 6 years post-removal on a North Pennine estate near Alston in England, showing extensive areas of bare peat and overland flow occurrence. Credit: Jess Fior-Berry.

Ditch drainage is also frequently used alongside some tracks to alleviate damming effects and reduce overland flow. However, ditches are associated with increased macropore and pipe formations as a result of desiccation which can lead to gully formation over time [23].

Compression effects have also been found, with even low rates of vehicular passage resulting in significant long-lasting compaction to the peat. An unsurfaced track driven over 24 times exhibited a density in the ruts three times greater than that of undisturbed reference areas more than seven years post-abandonment. While surfacing a track alleviates some compression at lower usage rates, the pull-down of a mesh geogrid as vehicles pass over spreads this impact over the width of the track, rather than focusing it solely in the ruts [24]. This creates less pronounced ruts but broadens the overall footprint of the track.

Where tracks are intended to be ad hoc unsurfaced or temporarily surfaced, the effects may far outlast the lifespan of the track. However, for brief periods such as during restoration, a temporary surface may be beneficial in reducing overall impacts (figure 6).

Figure 6. An unsurfaced track created during restoration of a site on the Isle of Lewis, Scotland, shown approximately 3 years post-completion of restoration work. In this case, a temporary surface may have helped ameliorate damage. Credit: Jess Fior-Berry.

Wear of vehicle tyres is also one of the most significant sources of terrestrial microplastics globally [25 26]. Usage of vehicles on peatland tracks will introduce plastics that would otherwise not have been present. There is also limited but contradictory evidence around the impact of deposition of other particulate matter and chemicals onto peatlands. A study of bog sites in Canada found that chemical deposition from road dust locally enriched areas of the study sites (with variable levels of phosphorous, carbonate and nitrate) leading to altered vegetation composition [27]. However, on an unspecified wetland type site, gravel road dust deposits were not found to significantly impact soil or water quality [28].

A geogrid track may be used with the intention that it will later be abandoned but left in place, to minimise the disturbance associated with removal. However, there must be consideration given to the potential for impacts resulting from microplastic deposition from the gradual breakdown of geogrids, as these have been documented to impact plant health [28] and act as transporters for organic contaminants [29].

Controlling access

Unmade tracks are less regulated; however, on SSSI land they may still be subject to consent which is discussed in the section ‘technical considerations’. For larger stone constructed tracks and development, they are generally subject to formal planning regulations.

While a track may be intended for a specific and sometimes limited use, peatlands are often remote in nature and controlling who or what uses a track may be difficult. As peatlands can be difficult to negotiate, a track, even if intended to be temporary, provides an easy access route for animals and people to cross areas. Where they truncate off other larger roads or tracks, they may encourage people to access areas that they otherwise would not, leading to unintended and sometimes extensive impacts (figures 7a and 7b).

Figure 7.a Damage caused by illegal off-road vehicle usage on peatland roads; a. ruts caused by two single passes from an off-road motorbike approx. 10 months after creation on Moor House National Nature Reserve in England’s North Pennines. Credit: Jess Fior-Berry.

Figure 7.b Excessive usage by four-wheel drive off-road cars on a 'C road' resulting in extensive impacts to the surrounding shallow peat surface on a North Pennine dry heath SSSI. Credit: Jess Fior-Berry.

However, there are specific purposes for which a track may be a useful addition to the land. Boardwalks found in places like RSPB Forsinard Flows Nature Reserve in the Flow Country may facilitate access in a way that limits damage while allowing visitors to appreciate and learn about the landscape. These may be acceptable trade-offs, particularly where open access may otherwise increase footfall but without an educational element that serves to encourage people to think about their influence on these fragile areas. However, care should be taken in creating all access routes, as there is an accompanying footprint which will lead to inevitable habitat impacts no matter how well planned.

How access for one purpose will influence others should be a key consideration during the decision-making process for track creation, in order to limit unintended damage.

Technical considerations on the bearing capacity of peat in relation to temporary geogrid tracks and floating tracks

The poor load bearing capabilities of peat itself are widely acknowledged [30] [31]. However, the load bearing capabilities of the track type should also be considered in the construction process, with consideration given to which type of vehicles will use the track and at what frequency.

To illustrate this: the maximum tensile strength of the active acrotelm layer has been found to range between 2.9-7.6 kPa [32]. Once the active living layer is lost, the peat below has virtually no tensile strength, due to its high water content and more decomposed structure. The ground pressure of a tracked Argocat – one of the lowest ground pressure vehicles available – is 4.6 kPa, whilst the ground pressure of an Argocat without tracks is ~14.5 kPa. For heavier vehicles this will be much increased, demonstrating the challenges involved in creating access routes on peatlands which can withstand regular usage.

For a HDPE mesh geogrid track with a maximum tensile strength of ~14 kPa (as per producer Terram technical specifications), this means that these tracks cannot provide sufficient protection to the peat where regular access is required. Indeed, by the end of a study at Moor House National Nature Reserve in England's North Pennines, an experimentally laid track had broken in areas driven over by an Argocat 156 times (Figure 8) [5] . As with the loss of the active layer, if usage continues when a track disintegrates, there is no protection for the underlying peat. However, care must be taken when extrapolating findings from single studies, as the fibrous content of peat has significant influence over the primary and secondary consolidation patterns of peat [33] and thus its load bearing capabilities.

Figure 8. Mesh track showing disintegration and water channelling in ruts as a result of vehicular passage. Credit: Jess Fior-Berry.

However, these surfaces may have useful application in restoration projects, where they could feasibly be rolled out on to the surface for short periods before being removed and used elsewhere as an alternative to using log tracks or unsurfaced tracks.

Tracks or roads may be constructed as part of windfarm access, and while windfarm construction on deep peat areas should be avoided, in many areas this has already occurred. At the time of writing, we are seeing an increased number of applications for renewable energy development on peatlands in all four UK nations. These developments will all include an element of new track construction if they are consented. Windfarm access requires heavier engineered tracks which have greater load bearing capabilities: the most common types of stone surfaced track are cut and fill and floating tracks.

Cut and fill tracks require excavation of the peat to the bedrock which displaces the carbon store, increases instability in the peat, and additionally generates a large quantity of spoiled peat. Floating track displaces less peat and does not require drainage ditches; however, it compresses the peat, and it cannot be constructed on slopes of gradient greater than 5%, meaning it is very limited in use. Over time, as the ‘floating’ track subsides due to compression of the peat beneath, it is top dressed with additional stone to create an even running surface. Over time, the increased weight of the track materials, weight of the vehicles using the track and further compression of the peat often causes a floating track to sink to the base of the peat profile. This means that they effectively behave as an excavated track would, which may compromise the integrity of mitigation infrastructure such as drainage pipes (figure 9).

Figure 9. A floating road that has sunk and snapped the drainage pipe which was constructed to provide cross track water flow to mitigate for the hydrological impact of the track. Credit: Ian Thomas, SEPA.

Is the consenting process and compliance monitoring process adequate?

Both the creation of infrastructure and the use of vehicles on protected peatland sites are generally listed as operations requiring consent from a statutory body. The most common unsurfaced tracks often form vast networks across the landscape. In England, a study found that the density of tracks was ten times greater than that of the public road network, on nominally protected upland peatlands. The density on protected peatlands averaged 1.76 (± 0.19) km km^{-2} compared to a density of 0.17 km km^{-2} for the public road network, which is equivalent to a density 10 times greater [35]. Given the observed densities and known versus unknown impacts, **it does not seem feasible that consent has been granted for such widespread ad hoc track networks, or where it has, that existing consents are still fit for purpose**. This highlights the need for greater recording and mapping of all tracks that are permitted or planned so that historic, cumulative impacts in any given area can be assessed and used to inform future consents. Temporary tracks are designed to improve the bearing capability of the peat whilst avoiding the issues associated with heavier stone or wood tracks sinking or adding nutrient to the peat. However, the removal of temporary tracks has been found to have a range of detrimental effects, whilst abandonment means leaving large amounts of plastic of unknown fate or impact in the landscape.

Research from the UK, which evidenced a range of impacts on the ecological and physical properties of a blanket peat site in the North Pennines, highlighted that restoration work would benefit recovery. However, it also concluded that the impacts were wide ranging, such that consent for tracks should only be granted where a clear need can be demonstrated that is in the interest of the broad public [7 14 21]. Given the paucity of evidence around impacts, greater research is required. It has been suggested that the onus to fund this research should fall to those who are likely to benefit from the construction of the infrastructure, rather than public funding bodies. We also recommend that statutory agencies build in monitoring requirements as part of the consenting process.

Recommendations

1. Mapping impact: The cumulative impact of tracks - consented, permitted and ad hoc - on UK peatlands is unknown. To allow for informed future consenting, mapping of existing tracks across peatlands could be conducted. Local authorities and statutory agencies will have access to some existing data on tracks although it may be easier to utilise remote sensing and AI to identify and map current UK track impacts on peatlands.
2. Assess current compliance measures and mitigation - are they working? A large body of evidence exists in the private and public sectors as a result of compliance monitoring on a variety of track access types on UK peatlands. Access to this data would allow for a more wide-ranging UK analysis of the historic impact of tracks. Meta analysis of existing data may also give a view on whether existing compliance measures and mitigation are effective in protecting peatlands.
3. Fund future research to address the following knowledge gaps:

- The fibrous content of peat is influential on the patterns of primary and secondary consolidation. This makes extrapolation of behaviour of the substrate more challenging from one region to another, both locally and globally. A study which assessed the characteristics of peatlands globally could be extremely useful in understanding how responses to construction and vehicular passage more broadly may differ across peatland types.
- Studies into the suitability of a given track type for the purpose it is intended for are urgently required. This is particularly true of HDPE plastic mesh tracks which represent a significant amount of plastic exposed to potential extreme weather conditions, and on removal break up to produce significant amounts of plastic fragments. At the end of their lives, if the bulk of the track is removed and disposed of elsewhere, this still represents a large amount of plastic waste.
- Natural pipe occurrence is well documented in peatlands and denser networks can form where there have been human management disturbances such as drainage. The desiccation of eroded surfaces has also been found to lead to increased pipe incidence. There have been no studies on natural peat pipe occurrence under or near to roads or tracks. This would be a useful area of study as pipes are known to be dynamic in nature and important to, and able to alter, both the hydrological function and carbon balance of peatland sites.
- Tracks create considerable expanses of bare peat during removal, which remain present for long time frames without intervention and are vulnerable to recolonisation by opportunist non-bog species. Restoration of these areas presents an important solution, but there is currently no research on peatland restoration post-track removal or abandonment in the UK. Colonisation post-construction or re-colonisation post-removal, by invasive or non-bog plant species may also lead to an outward spread into the wider habitat, meaning there is also a need to understand how best this can be minimised.

Glossary

Acrotelm: The ‘active’, living layer of a peatland, approximately the top 10 cm of vegetation on the surface.

Catotelm: The ‘inactive’, decomposing layer of a peatland where the slowly decaying plant matter builds up in the waterlogged anoxic conditions.

Diplotelmic: Two layered acrotelm-catotelm model of peatlands. Although widely quoted the model is not wholly accepted and may be an oversimplification (for further reading see Morris et al., 2011 https://onlinelibrary.wiley.com/doi/epdf/10.1002/eco.191).

Geogrid: mesh often made of plastic used either as a part of a floating track or on its own as low usage track.

HDPE: High Density Polyethylene, a thermoplastic used to manufacture geogrid.

Microstructures: Surficial patterning formed by plants and physical processes e.g. hummocks, tussocks, pools and micro-erosion networks.

Tensile strength: The maximum load that a material can bear during stretching without subsequent failure/breakage.

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The International Union for Conservation of Nature (IUCN) UK Peatland Programme exists to promote peatland restoration in the UK and advocates the multiple benefits of peatlands through partnerships, strong science, sound policy and effective practice.

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