Commission of Inquiry on Peatlands Update: Peatland Catchments and Natural Flood Management

Plain English Summary

There is increasing interest in the use of Natural Flood Management (NFM) to reduce flood risk for vulnerable communities. NFM seeks to reduce flood risk by restoring or enhancing landscape processes and natural hydrological functions that have been damaged by human activities. Peatlands cover nearly 10% of the UK's land cover but few of our peatlands are in a near-natural state. Most have been damaged by drainage, air pollution, fire, erosion and other land-use pressures, and the last decade has seen a dramatic increase in the number of projects aiming to restore peatland landscapes. Many communities at risk of flooding have large areas of peatland in their upstream catchments, and it is increasingly common to see claims that peatland restoration can reduce flood risk. This report therefore reviews the evidence that restoration of peatlands can reduce the peak flows of rivers and so contribute meaningfully to NFM.

We have good understanding of how storm runoff is generated from peatlands and the changes associated with peat restoration that could contribute to NFM. Restoration may provide increased storage of flood waters in peatland. This is more likely to be associated with restoring surface storage in pools, hollows and depressions than (as is often assumed) through water storage in the peat itself. Any benefits of increased storage would be limited in large rainfall events. Restoration measures can also contribute to NFM by reducing how quickly stormwater moves into river channels ('slowing the flow'), so delaying and reducing flood peaks. The nature of the peat surface and the 'roughness' to stormflow presented by the peatland vegetation cover and vegetation type are key controls on this process.

Recent studies have measured or modelled the impacts of different types of peatland restoration on peaks flows in rivers and streams. Some of these have used field monitoring to directly measure change in flood peaks after restoration, but such monitoring is only appropriate in small catchments due to the need to eliminate other (non-restoration) factors. Assessments at larger catchment scales therefore use computer models to upscale the data from field measurements.

Material adapted from the technical report by Allott *et al.*, (2019) Commission of Inquiry on Peatlands Update: Peatland Catchments and Natural Flood Management.

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There is increasing evidence from these studies that peat restoration alters catchment runoff and can reduce peak flows and therefore contribute to NFM in small (<20 km^2) catchments. There is some evidence from modelling that the effects could extend into larger catchments**.** However, the evidence is not consistent across all types of restoration. We have high confidence that the re-vegetation of bare peat and the re-introduction of *Sphagnum* moss to degraded peatlands can reduce peak flows by slowing storm runoff on hillslopes. We also have field data showing that drain blocking can reduce peak flows through increased storage or by slowing flows, but modelling studies predict mixed results, including potential increases in flood peaks for particular orientations and characteristics of drainage. We currently have limited field data on the impacts on peak flows of gully blocking, peat restoration by forest removal, and severe wildfire plus subsequent recovery from fire, although our current understanding of the relevant hydrological processes predicts that gully blocking will reduce peak flows, while forest removal and severe fire will have the opposite effect, particularly immediately after disruption and if no efforts are made to restore deforested or burnt peatlands.

We therefore need more field studies of the impacts of several types of peatland restoration to improve our predictions of change in peak flow and to quantify potential NFM effects, particularly over timescales that are longer than 5 years. There is also a need for further refinement and testing of our models and the development of modelling capacity to provide more comprehensive, catchment specific assessment of the potential NFM benefits (or adverse effects where relevant) of peatland restoration interventions. These assessments need to be extended to catchments of different sizes and geographies, including more routinely for peatland catchments containing communities at risk of flooding and for rainfall/flood events of different sizes (return periods).

Key findings

1. There is increasing evidence from both field and modelling studies that peatland restoration measures can alter catchment runoff regimes, reduce peak flows and contribute to Natural Flood Management (NFM) at the small (<20 km^2) catchment scale, with some evidence from modelling that peak flow reductions could potentially extend into larger catchments.

2. Peatland surface and vegetation cover represent key controls on storm runoff, hydrograph and peak flow dynamics in peatland catchments.

3. The current evidence base for the NFM effects of key peatland restoration measures indicates that:

   a) Re-vegetation of bare peat leads to delayed and reduced peaks flows in small catchments.
   b) Initial data suggests the blocking of erosional gullies can delay and reduce peak flows at small catchment scales.
   c) Field studies of drain blocking generally report decreased peak flows from peatlands, but model studies indicate that blocking could also increasing peak flows depending on drain orientations and other local factors.
   d) Plot-scale and modelling studies predict that widespread re-introduction of *Sphagnum* to peatlands has the potential to reduce catchment flood peaks.
   e) Evidence largely supports the assumption that severely burnt peatlands will have flashier hydrograph responses to rainfall events, with higher peak flows relative to unburnt peatlands or peatlands restored after severe fire.
   f) Current understanding of forest hydrological processes predicts that the removal of conifer forest cover from peatlands could significantly increase flood peaks, and care will therefore be needed to minimise potential adverse effects of restoration of afforested peatlands.

4. The spatial location of restoration measures within peatland catchments will impact the potential NFM benefit.

5. There are still significant uncertainties in our understanding of peat restoration and NFM. We lack sufficient field data on the impact of several types of restoration measure on flow regimes, and we have limited data on hydrological responses to restoration over longer (>5 year) timescales. We also lack quantitative estimates of the scale of NFM effects of peatland restoration for flood events and catchments of different sizes.

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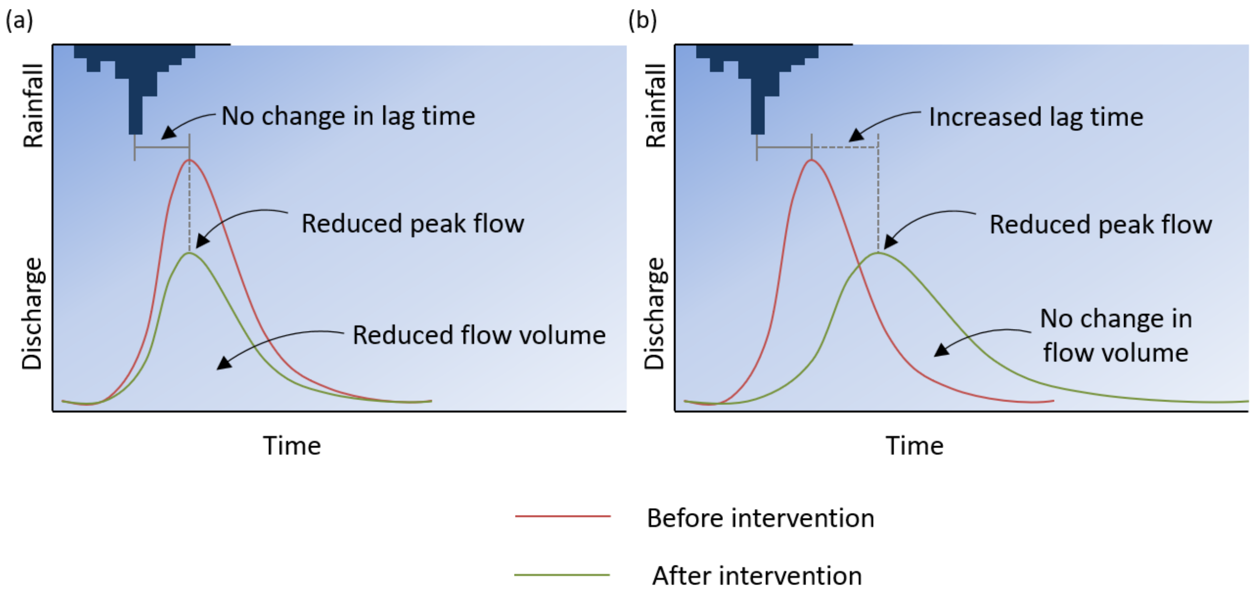
6. Although we can enhance the current evidence base by further monitoring of the impacts of land management and restoration on peak flows through the use of plot and small-scale catchment experiments, direct observation of the impacts on floods at a larger catchment scale (>20 km^2) is unrealistic due to confounding factors as scale increases.

7. More comprehensive modelling is therefore required both for catchment-specific assessments and for scaling-up to allow full quantification of the NFM benefits, and any possible adverse consequence, of peatland management and restoration at scales relevant to communities at risk of flooding. Appropriate modelling solutions are already available.

8. Ongoing projects and modelling programmes are addressing some of these uncertainties and evidence gaps, and substantial further progress in our understanding of peatlands and NFM is expected within the next 3-4 years.



Hypothetical river flood hydrographs showing the impacts on hydrograph peak flows and lag times of natural flood management (NFM) measures which (a) increase within-event storage in the catchment and (b) delay the conveyance of stormwater into river channels.

Recommendations and actions

There remains some uncertainty about the role in which peatlands have to play in NFM measures. One of the simplest ways to manage this uncertainty and incomplete scientific understanding is to highlight knowledge gaps and make recommendations for prioritising research. It is acknowledged that some of these gaps will be addressed by ongoing research projects within the next 2-4 years (e.g. NERC PROTECT-NFM, NERC Yorkshire iCASP, EU-Moorlife 2020, Exmoor Mires Project and South West Water 'Upstream Thinking' project). Bearing this in mind the following priorities for research remain:

a) A national- scale assessment is needed to locate and quantify areas of peatlands in the catchments of communities at risk of flooding, as well as to identify peatland catchments of relevance to other assets vulnerable to flooding (e.g. transport infrastructure), and to map the associated opportunities for peatland restoration. This will provide greater understanding of the potential for peatland restoration based NFM in both upland and lowland catchments.

b) More evidence is needed to quantify the impacts of restoration of lowland peatlands (raised mire and fen) on runoff and peak flows and the potential reductions in flood risk for downstream communities.

c) Additional field studies are needed to quantify the response of catchment flow regimes and peak flows for all relevant peatland restoration treatments. Data on the restoration treatments and scales where data are currently lacking should be prioritised, in particular:
   a. Small catchment studies of *Sphagnum* re-introductions;
   b. Impacts of gully blocking;
   c. Impacts of severe wildfire plus restoration and recovery from wildfire;
   d. Small catchment studies of the restoration of afforested peatlands by tree removal and drain blocking.

   We also need further studies of runoff regimes from intact (near natural) peatland catchments to provide reference data for peatland restoration.

d) In all cases research design and data collection should be informed by (i) hypotheses of hydrological response derived from current process understanding and (ii) the evidence and parameters needed to improve and test hydrological models and to reduce uncertainty in model simulations of catchment responses.

e) Longer term monitoring is required of key restoration experiments to more fully establish how NFM benefits of peatland restoration will evolve through time.

f) We have an increasingly large evidence base for the impacts of drain blocking on flow regimes, but this indicates that responses are catchment specific and depend on the nature and geography of the drain networks. Modelling applications are therefore needed across a wider set of catchments with varying drain network characteristics to confirm the types of catchments where reductions in peak flow following drain blocking would be expected, and to identify catchments where there might be adverse effects.

g) Further development and application of models are needed to improve quantification of the NFM impacts of peatland interventions and to check for possible negative hydrograph synchronisation effects within catchment systems. These need to be developed for and applied at catchment scales relevant to communities at risk. Model simulations should incorporate (i) more comprehensive evaluations of peak flow reductions and NFM benefits across a range of flood event sizes (return periods) including for extreme events and (ii) coupling of hydrological and inundation models to simulate impacts on communities at risk. Model applications need to be accessible to the practitioner community and should provide clear information on the uncertainty of model predictions.

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