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IUCN National Committee United Kingdom
Peatland Programme

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Peatland Catchments and Natural Flood Management

Report to the IUCN UK Peatland Programme's Commission of Inquiry on Peatlands Update

Tim Allott[1], Jorge Auñón[2], Christian Dunn[3], Martin Evans[1], Jill Labadz[4], Paul Lunt[5], Michael MacDonald[6], Tom Nisbet[7], Roger Owen[8], Mike Pilkington[2], Sarah Proctor[9], Emma Shuttleworth[1], Jon Walker[10]

[1]University of Manchester, [2]Moors for the Future Partnership, [3]Bangor University, [4]Nottingham Trent University, [5]University of Plymouth, [6]Royal Society for the Protection of Birds, [7]Forest Research, [8]Scottish Environmental Protection Agency, [9]IUCN UK Peatland Programme, [10]Swansea University

August 2019

Webinar for NERC Natural Flood Management Research Programme

16 July 2020

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Peatland Programme

IUCN Commission of Inquiry on Peatlands

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- Ongoing programme project to summarise research relevant to policy makers
- Six technical reports produced in 2019
- Summary assessment report and inquiry outcomes due in 2020
- **Aims of the Peatland Catchments Report**
    - Summarise the recent science around peatland restoration and management and catchment-scale hydrology;
    - Review the evidence base for the impacts of peatland restoration and management on river flows and runoff in peatland catchments;
    - Assess the current evidence for Natural Flood Management (NFM) benefits from peatland restoration;
    - Identify key remaining evidence gaps for the links between peatland condition and restoration and river flood dynamics;
    - Make recommendations on future research and evidence gathering priorities for policy development.

Natural flood management (NFM)

Managing flood risk by protecting, ***restoring*** *and emulating the natural regulating function of catchments and rivers*, [with] the potential to provide environmentally sensitive approaches to minimising flood risk, to reduce flood risk in areas where hard flood defences are not feasible, and to increase the lifespan of existing flood defence

(NERC, 2017)

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Upland peatlands in the UK

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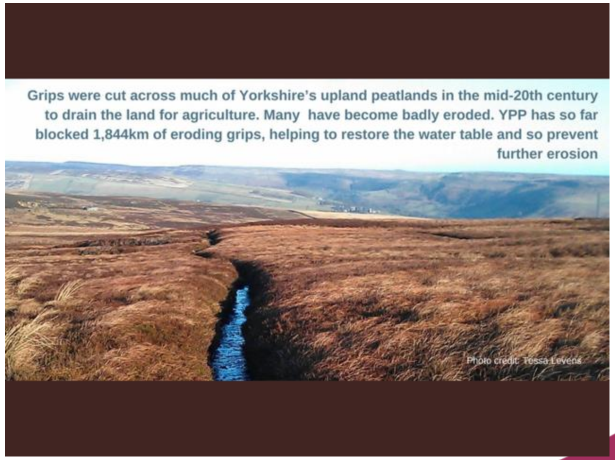
- Peat forming landscapes cover c.10% of UK land cover and c.60% of uplands
- Highly productive of runoff
- Only c.20% are in near natural state (‘intact’)



Investment in peatland restoration for multiple benefits (carbon, biodiversity, water regulation)

Press release

New £10 million fund to restore peatland

A £10 million fund will help protect and restore England's iconic peatlands

Published 14 April 2017
From: Department for Environment, Food & Rural Affairs, Natural England, and The Rt Hon Thérèse Coffey MP

A £10 million grant scheme to restore England's iconic peatlands has been launched by the Government today.

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Scottish Budget 2020-21

February 7, 2020

The Scottish Government has published its budget for 2020/21 in which it provides £20 million for peatland restoration and a commitment to invest £250 million over the next ten years. This has been agreed as part of the Scottish Governments commitment to nature-based solutions to the climate crisis and described as "an absolute game changer for CO_2 emissions reductions, biodiversity and the rural economy" by Roseanna Cunningham, Cabinet Secretary for Environment, Climate Change and Land Reform.

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UK Peatland Restoration

demonstrating success

Peatland catchments and communities at risk from flooding

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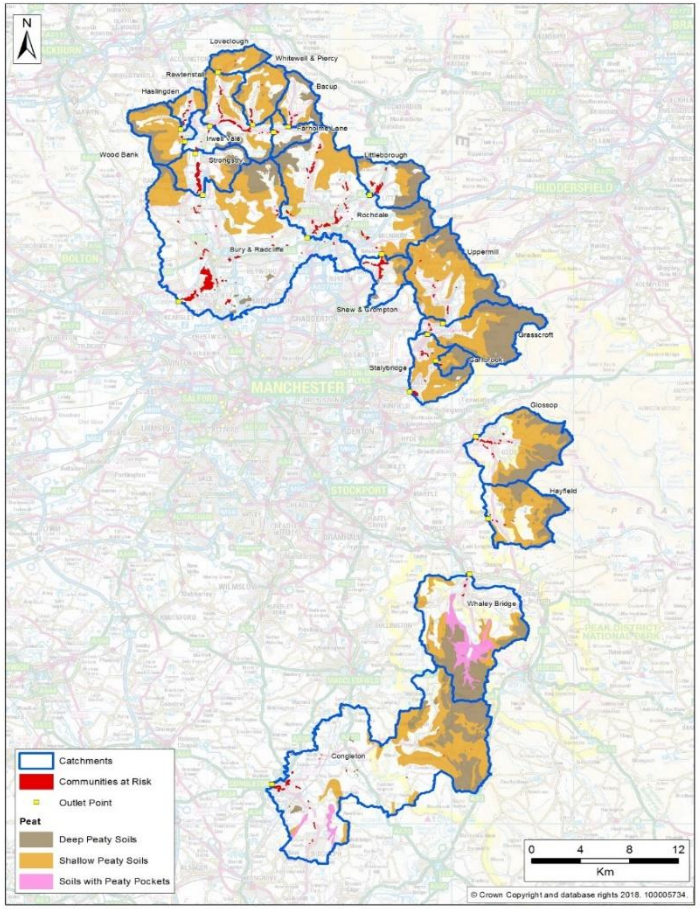
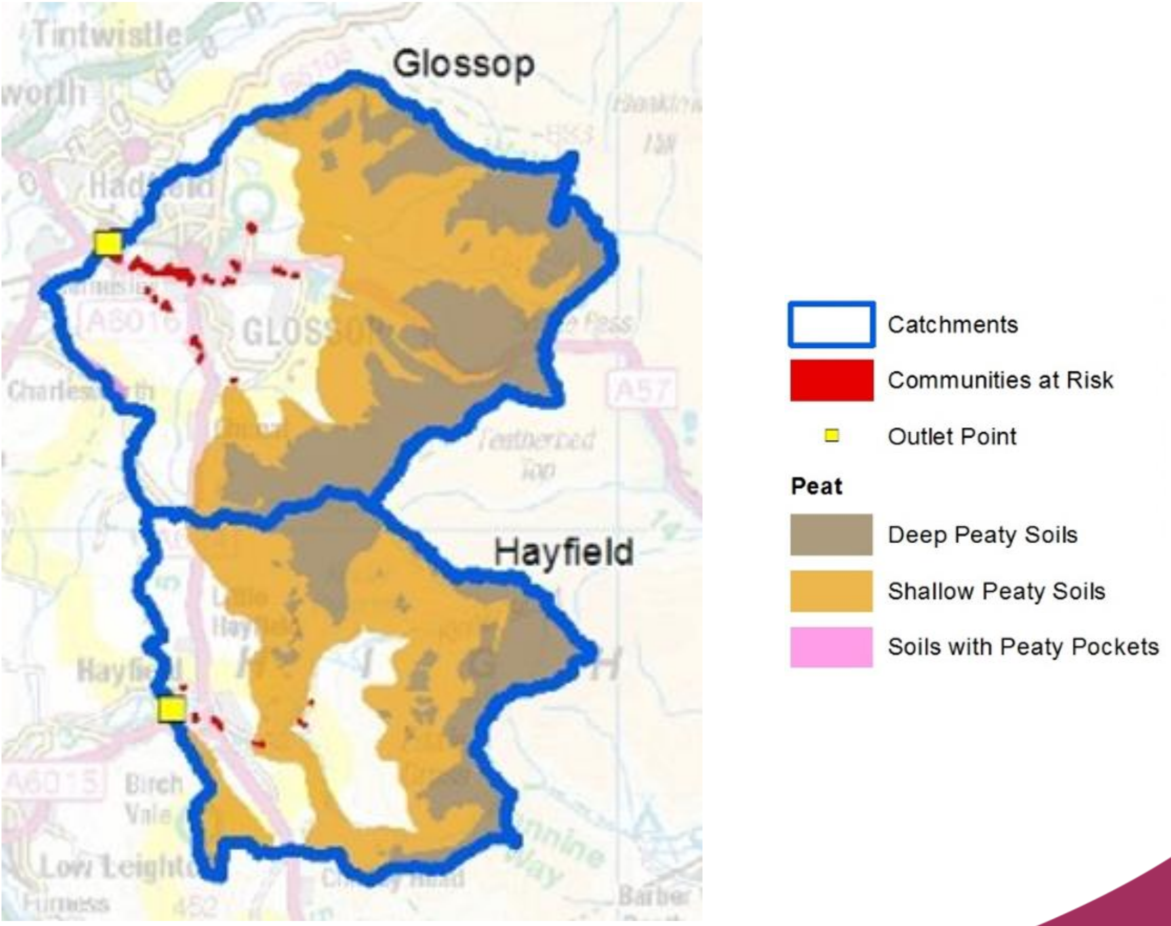
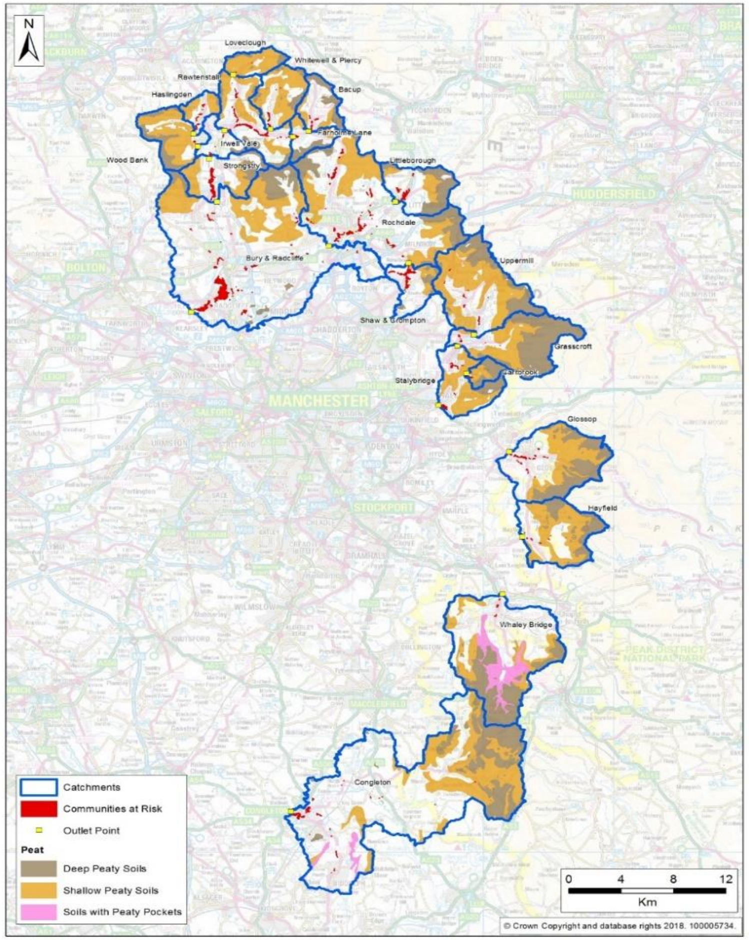
West Pennine pilot study (EA GMMC region)





MOORS FOR THE FUTURE PARTNERSHIP

Catchments at Risk (CoR)
West Pennine pilot study (EA GMMC region)



- 22 catchments at risk (C@R) of flooding
- 11,500 properties at risk of flooding

- 12 of the 22 catchments are ‘small’ (< 20 km^2) *sensu* Dadson *et al* (2007)
- 3664 properties at risk of flooding in small catchments
- 20 of the 22 catchments contain >20% cover of peaty soils

- Nearly 2000 properties at risk in catchments where deep peat cover exceeds 25% of the catchment area

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Review contents

Peatland Catchments and Natural Flood Management

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August 2019

- **Introduction and context for the review**
- **The process-based case for peatland restoration and natural flood management**
  - The potential for NFM in peatland catchments
- **Peatland catchments and communities at risk from flooding**
  - West Pennines case study
- **Peatlands, restoration and NFM: the evidence base**
  - Peatland drainage and drain blocking
  - Restoration of bare peat
  - Gully blocking
  - Sphagnum re-introduction to degraded peatlands
  - Forestry and restoration of afforested peatlands
  - Moorland burning and peat restoration following wildfire
- **Evidence gaps and priorities for future research for policy**
- **Conclusion and recommendations**

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Conceptual basis for NFM in peatland catchments

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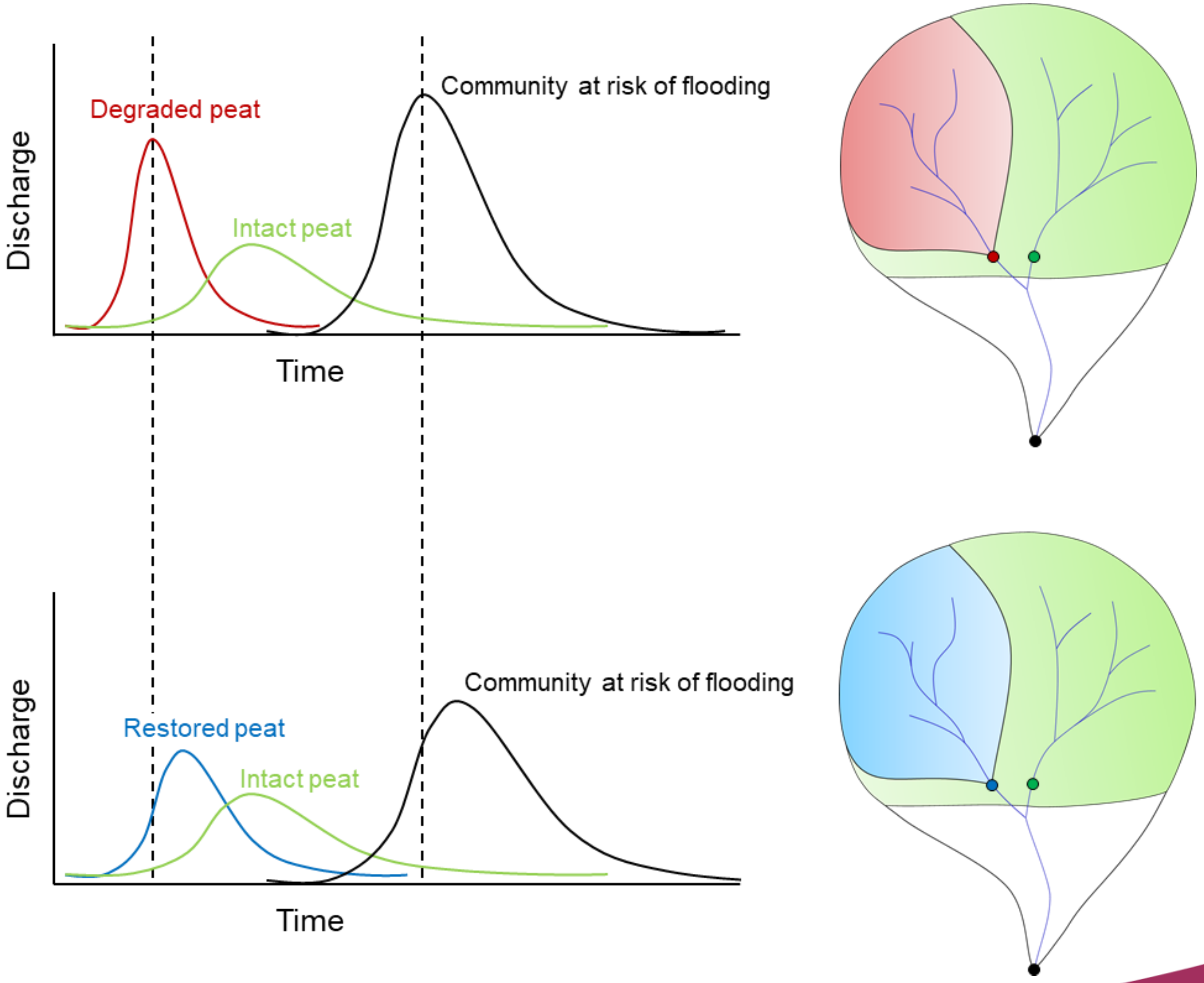
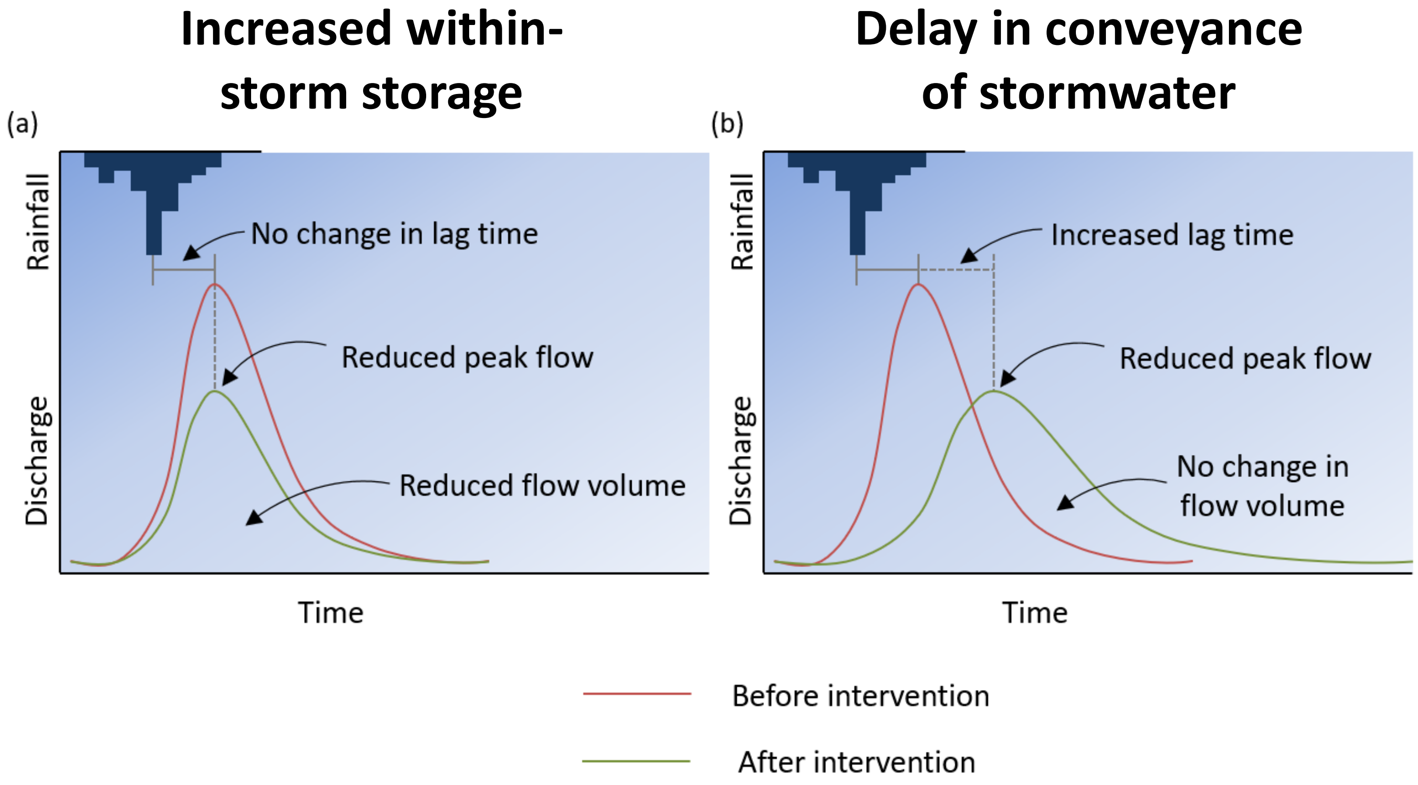


Process-basis for Natural Flood Management from peatland restoration



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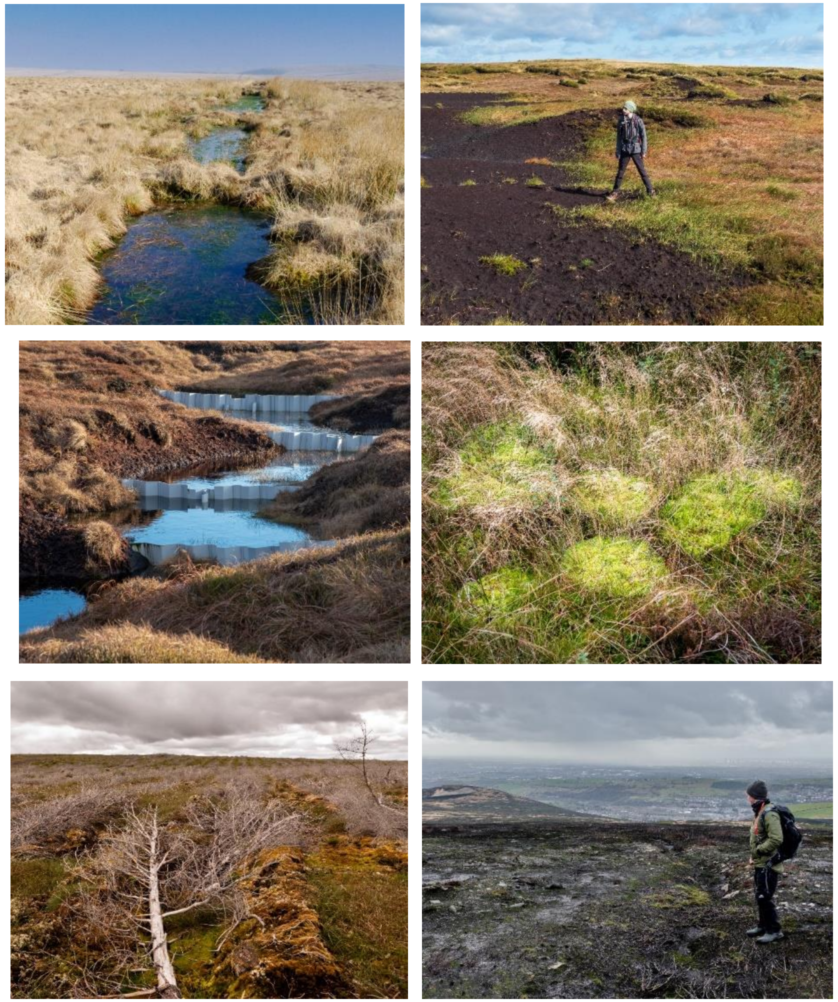
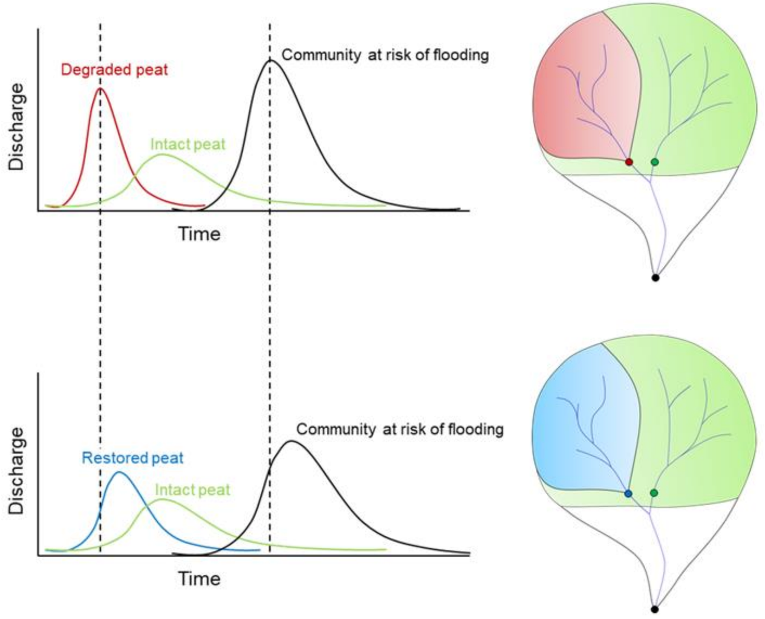
Peatland Restoration Interventions



- Restoration of bare peat
- *Sphagnum* moss re-introduction to degraded peatlands
- Peatland drainage and drain blocking
- Gully blocking
- Forestry and restoration of afforested peatlands
- Moorland burning and peat restoration following wildfire

Nature of the Evidence Base: Process studies and importance of recent **Catchment Scale** assessments

Study	Grayson et al. (2010)	Gatis et al. (2015)	Holden et al. (2017)	Shuttleworth et al. (2019)	Ballard et al. (2012)	Lane and Milledge (2013)	Milledge et al. (2015)	Gao et al. (2016)	Gao et al. (2017)
Location	Trout Beck, North Pennines, England	Exmoor, southwest England	Migneint, north Wales	Ashop, Peak District, England	Wharfedale, Yorkshire Dales, England	Wharfedale, Yorkshire Dales, England	Ashop, Peak District, England	Trout Beck, Pennines, England; Wye, Wales; Dart, southwest England	Coverdale, Yorkshire Dales, England
Approach	Empirical (Before-After natural revegetation study)	Empirical (Before-After-Intervention experiment)	Empirical (Before-After-Control-Intervention (BACI) experiment)	Empirical (Before-After-Control-Intervention (BACI) experiment)	Modelling (Simulation of intact, drained and blocked drain scenarios)	Modelling (Simulation of drained vs intact catchment scenarios)	Modelling (Simulation of restored vs unrestored catchment scanarios)	Modelling (Simulation of revegetation scenarios)	Modelling (Simulation of revegetation and burning scenarios)
Peatland Type	Blanket peat	Blanket peat	Blanket peat	Blanket peat	Blanket peat	Blanket peat	Blanket peat	Blanket peat	Blanket peat
Restoration Type	Natural revegetation	Drain blocking	Drain blocking	Revegetation of bare peat and gully blocking	Drain blocking	Drain blocking	Revegetation of bare peat and gully blocking	Land cover change (Sphagnum reintroduction)	Land cover change (vegetation restoration)
Catchment Size/s	11.4 km^2	19.5 – 46.5 ha	1 – 2.5 ha	0.5 – 0.7 ha	4 ha	13.8 km^2	c.9 km^2	10.6 – 21.5 km^2	84 km^2
Summary of changes in storm hydrographs and peak river flows	Revegetation is associated with significantly less 'peaky' storm hydrographs and lower flood peaks per unit rainfall.	22-35% reductions in peak flows. No change in storm hydrograph lag times.	Immediate 5-fold decrease in peak flows within drainage ditches, but subsequent lagged responses of increasing peak flow suggest this does not represent steady state.	Revegetation reduced peak flow by 27% and increased lag times by 106%. Additional gully blocking reduced peak flow by further 24% and increased lag times by further 94%.	Predicted drainage would generally increased peak flows, but effects of drain blocking dependent on local conditions and could increase or decrease peak flows.	Predicted the dominant effect of drain blocking in the study catchment would be to produce higher peak flows and lower base flows.	Predicted peat restoration in 12% of study catchment would reduce peak flow by 5%.	Predicted Sphagnum reintroduction would reduce peak flow of 1 in 10 year event by 12.8%, 1.8% and 19.6% in three study catchments.	Predicted Sphagnum reintroduction in study catchment would reduce peak flow of 1 in 10 year event by 5.2%.



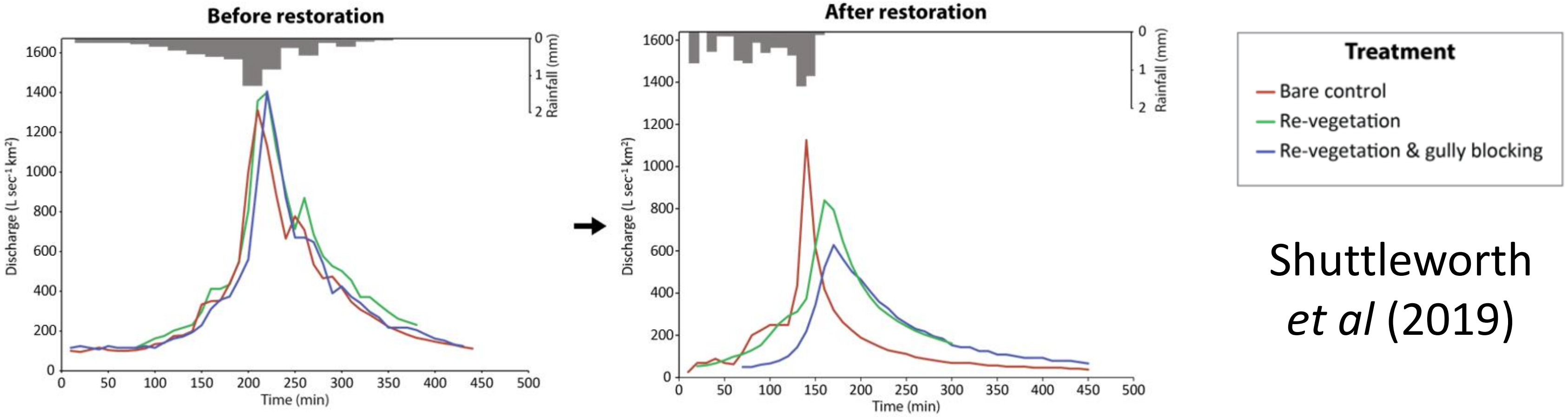
- Mix of field and modelling studies
- Range of catchment sizes (<1 ha to 85 km^2)

- Field studies include Before-After and full Before-After-Control-Intervention (BACI) studies
- Field studies typically based on very small (<1km^2) catchments

- Four of ten studies focus on drain blocking
- Six studies focus on changes in peat surface cover and vegetation

- ***Data from these catchment-scale studies tests our understanding from process / plot-scale studies***

Revegetation of Bare Peat



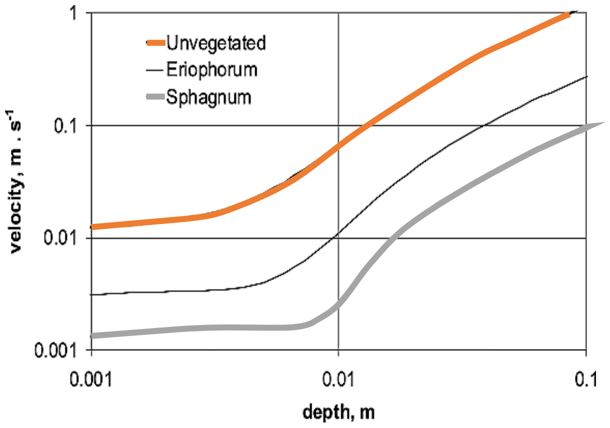
Shuttleworth *et al* (2019)

- Significantly delayed and reduced peak flows in small (headwater) catchments
- Key process control is reduction in overland flow velocity due to increased surface roughness
- Quantified through plot-scale, catchment monitoring and BACI experiments

Sphagnum Planting

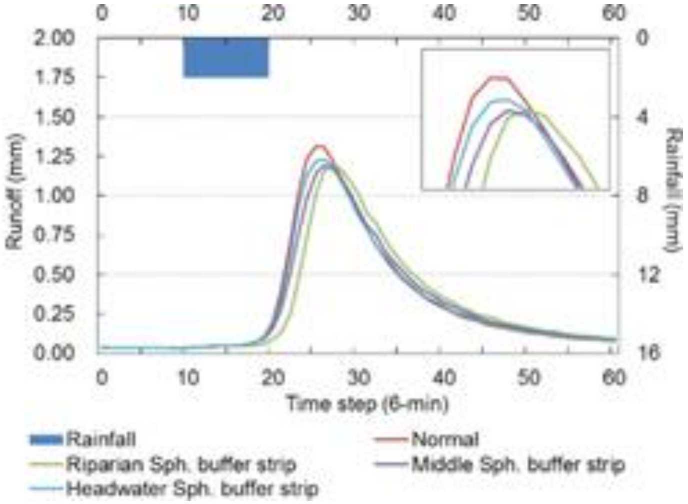
Sphagnum and runoff – in Theory

Plot scale experiments



Holden et al (2008)

Modelling work



Gao et al (2018)

- Plot-scale and modelling studies demonstrate potential to reduce catchment flood peaks in small to medium sized catchments
- Key process control is reduction in overland flow velocity due to increased surface roughness
- Effect has not yet been demonstrated by monitoring at catchment scale

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Drainage and Drain Blocking

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Brown syke grip © Andrew Keen

©South West Water

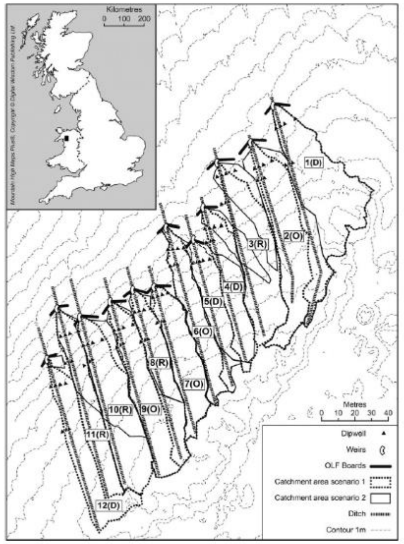

FIGURE 1 Map of the study site showing the 12 ditches and their catchment areas for Scenario 1 and Scenario 2, the treatments (O = open, D = dammed, R = reprofiled), location of each ditch weir and overland flow soffit boards, and the location of the dipwells

Holden et al (2017)

- **Field studies generally report decreased peak flows following blocking**
  - Diversion of drainage onto hillslopes (increased travel times)
  - Increased within-storm storage (i.e. Exmoor case study on a shallow peat system)
- **Modelling studies indicate that in some cases blocking could increase peak flow**
- **Impact dependent on nature of the drains and the orientation and density of the drain network**
  - Blocking downslope drains most likely to reduce peak flows
  - Blocking smooth (poorly vegetated) drains more effective than blocking well vegetated drains

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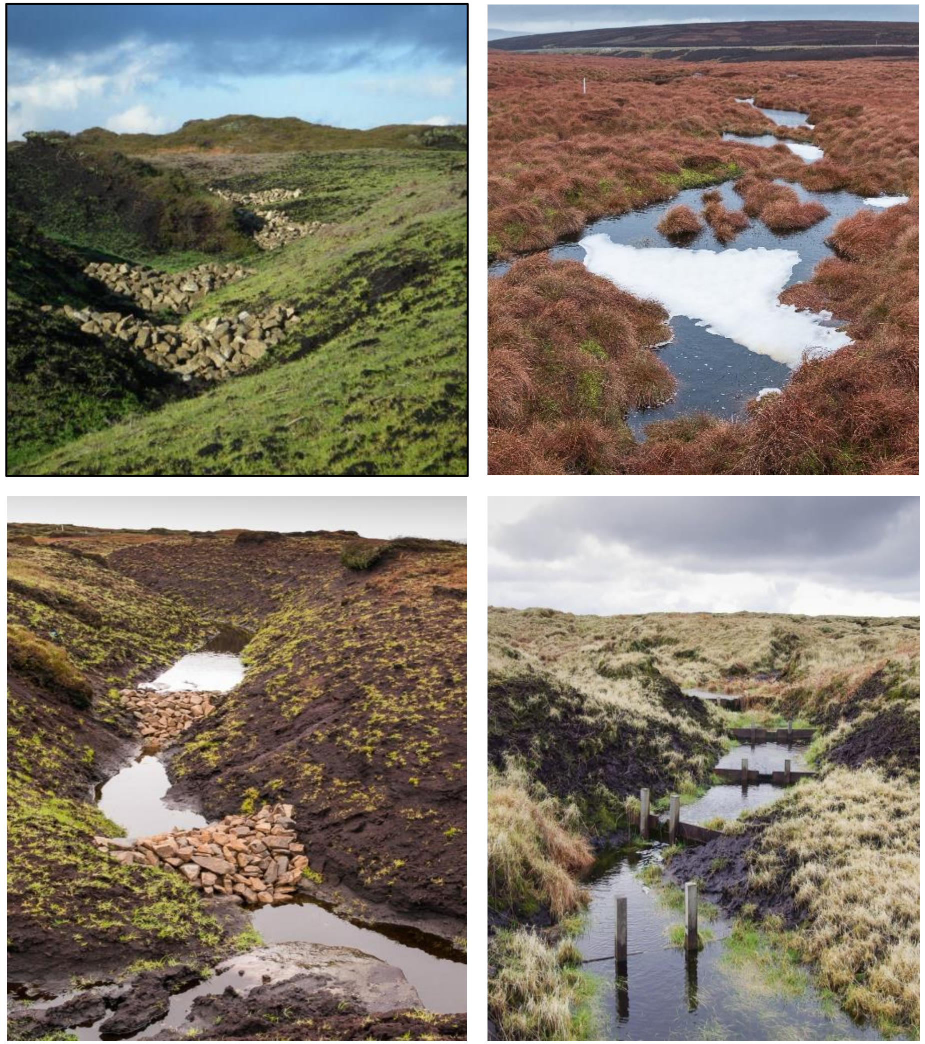
Gully Blocking



- Gullying extensive in UK blanket peatlands
- Increasing use of gully blocks within restoration projects
- Peat dams, wooden dams, stone blocks

- Potential for both storage and attenuation (roughness) effects on storm hydrographs

- Initial evidence from stone dams suggests they reduce peak flows at small catchment scales
- But quantification is limited and further data are needed

Restoration of Afforested Peatlands

Hancock *et al* 2018

- **Hydrological effects of afforestation on peatlands are complex**
- Afforested peatlands are also drained
- Observations of the impacts of restoring afforested and forest-drained peatland on catchment runoff are sparse
- Process studies show forests generally evaporate more water than shorter types of vegetation, with drier soils, reduced runoff and lower catchment water yields
- Forest cover can reduce flood peaks, with the greatest impact on small and medium flood peaks
- **Removal of forest cover from peatland could increase flood peaks**
- Care therefore needed to minimise potential adverse effects of restoration of afforested peatlands

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Burning on Peatlands

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- Process-based and plot-scale evidence suggests severely burnt peatlands will have flashier hydrographs and higher peak flows
- Current process understanding suggests the effects of severe wildfire on peak flows could be substantial

- But limited data on impacts of peatland burning on **catchment-scale** runoff and peak flow

- University of Leeds EMBER study monitored prescribed burn vs non-burnt catchments. Concluded burnt catchments “slightly more prone to higher flow peaks” but authors state not conclusive due to research design (spatial comparison study)

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Evidence Base for Impacts of Peatland Restoration on Peak Flows

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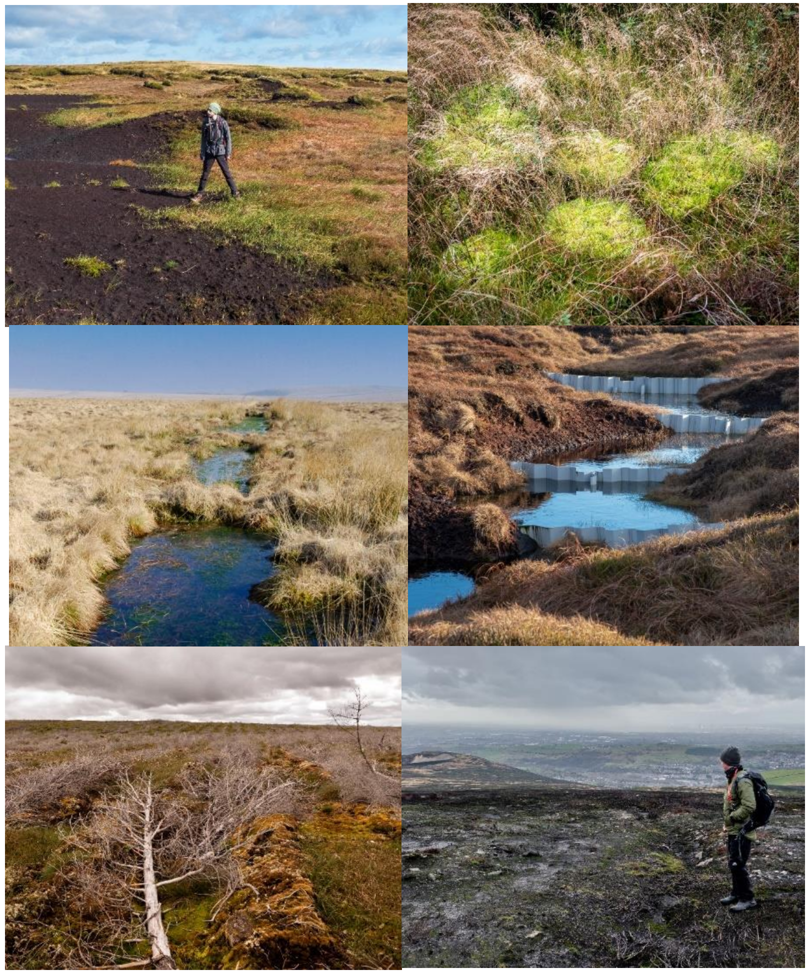

Restoration Measure	Impact on Peak Flows
Re-vegetation of bare peat	↓
Re-introduction of Sphagnum	↓
Gully blocking	↓
Restoration after severe fire	↓
Ditch blocking	Variable
Commercial forest removal	↑

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Evidence Base for Impacts of Peatland Restoration on Peak Flows

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Increasing evidence that peatland restoration can alter catchment runoff regimes and reduce peak flows at the small (< 20km^2) catchment scale

Key Knowledge Gaps

- Lack data on the impact of several key types of restoration
- Need better understanding of hydrological responses to peatland restoration over longer (>5 year) timescales
- Require more complete assessments at flood-relevant scales (Communities@Risk, fuller range of flood return periods)

Timescales of NFM benefit following restoration of peatland catchments

Evolution of gully blocks: changing NFM benefit through time?

How long will it take for *Sphagnum* reintroduction to impact runoff?

We lack quantification of the NFM impacts of peatland intervention for full range of flood-relevant events and catchments sizes

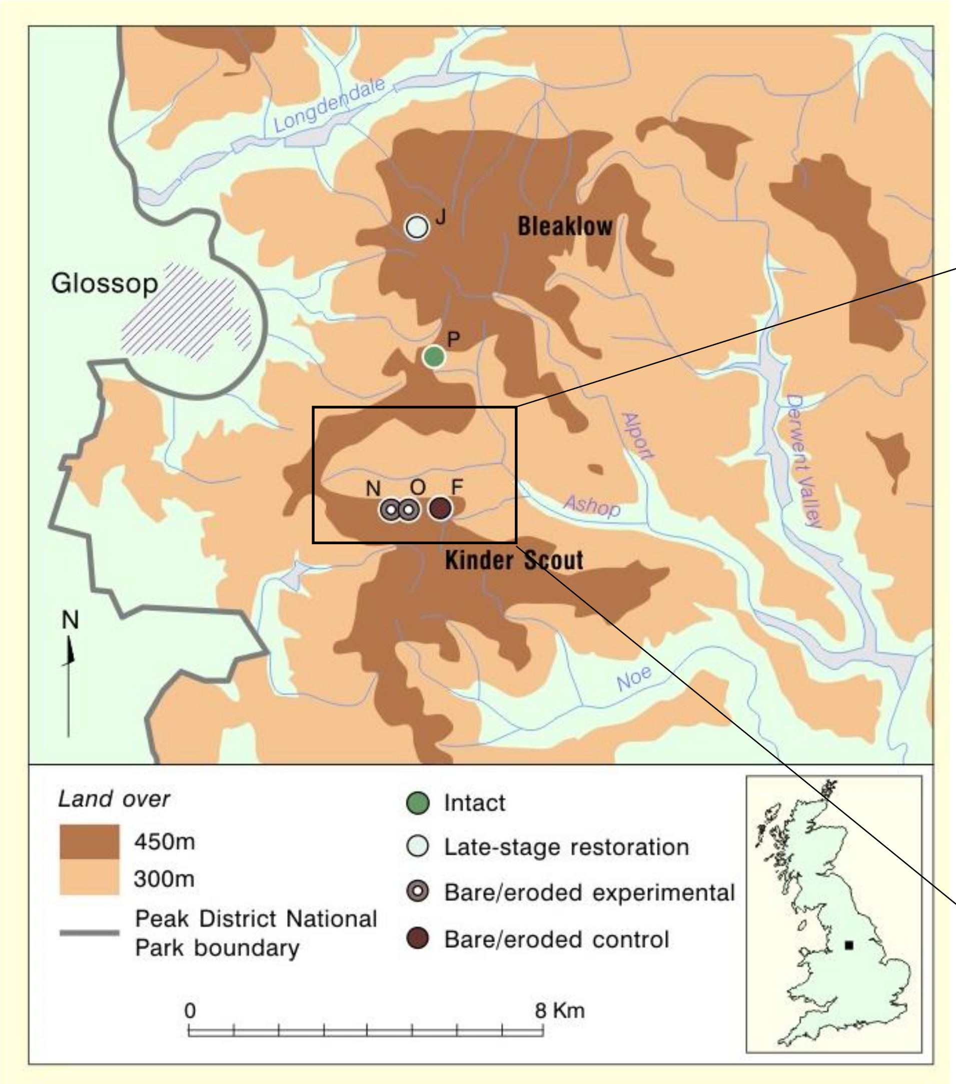
19 km^2

38 km^2

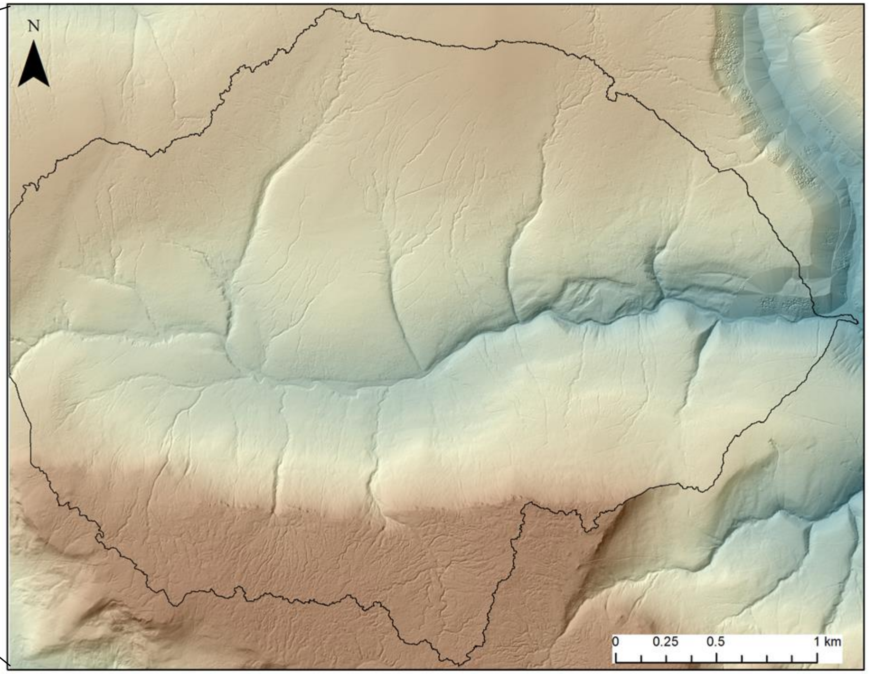
> 1 in 50 year event

- We need evidence of efficacy for larger storms (> 1-in-10 year events) and for medium to large catchments (>20 km^2)
- Direct detection at these scales unrealistic
- Expanded modelling efforts required
- Appropriate modelling solutions are available, but need to be carefully parameterised, calibrated and tested using (small catchment scale) empirical data

Can it contribute at meaningful scales? Model Upscaling

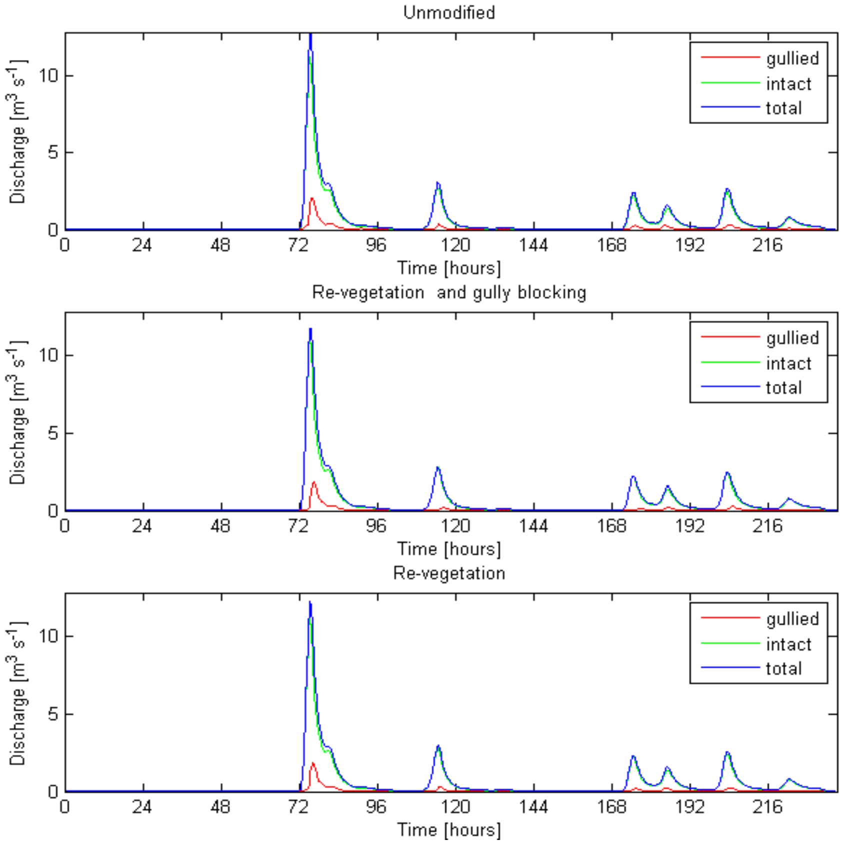


- Micro-catchments (N,O,F,P): c. ½ ha
- Upper Ashop catchment: 9 km^2
- ~17 % eroded and gullied peat



Milledge et al. (2015)

Can it contribute at meaningful scales? Model Upscaling



- **Upscaling from ½ ha to 9 km² with 12% of the catchment modified we find that :**
  - Re-vegetation alone reduces peak discharge by up to 5 %
  - Re-vegetation & gully blocking reduces peak discharge by up to 8 %,
  - Complete recovery might reduce peak discharge by up to 10 %.
- The results are sensitive to assumed overland flow and channel velocities, these can be calibrated to reduce the uncertainty

Milledge et al. (2015)

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Can it contribute at meaningful scales? Model Upscaling

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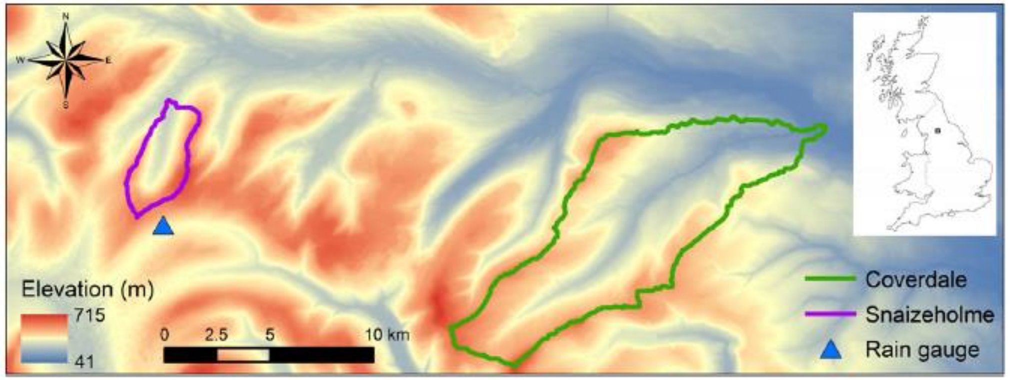
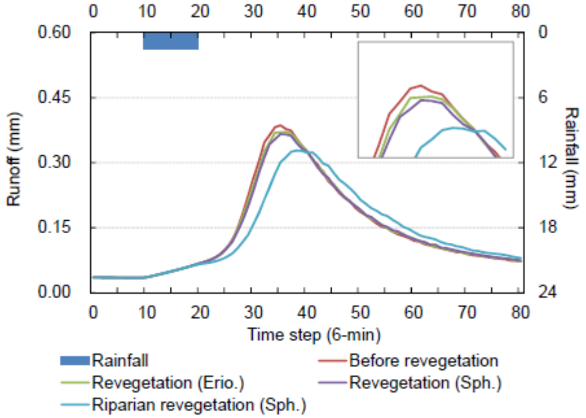
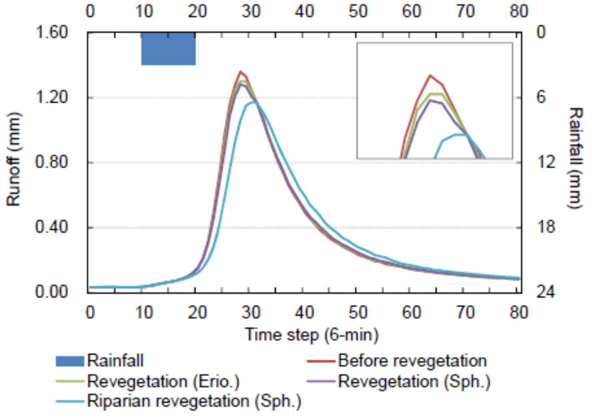
Gao *et al* (2016) – Modelling peat re-vegetation (*Sphagnum*) in Coverdale catchment (84 km^2)







- **Impact of restoration scenarios for the 1-in-10 year rainfall event**
- Vegetation restoration with *Sphagnum* to the 5.8% of the catchment with bare peat predicts a 5.2% reduction in flood peak
- Riparian *Sphagnum* planting of the same sized area predicts a 15% decrease in flood peak

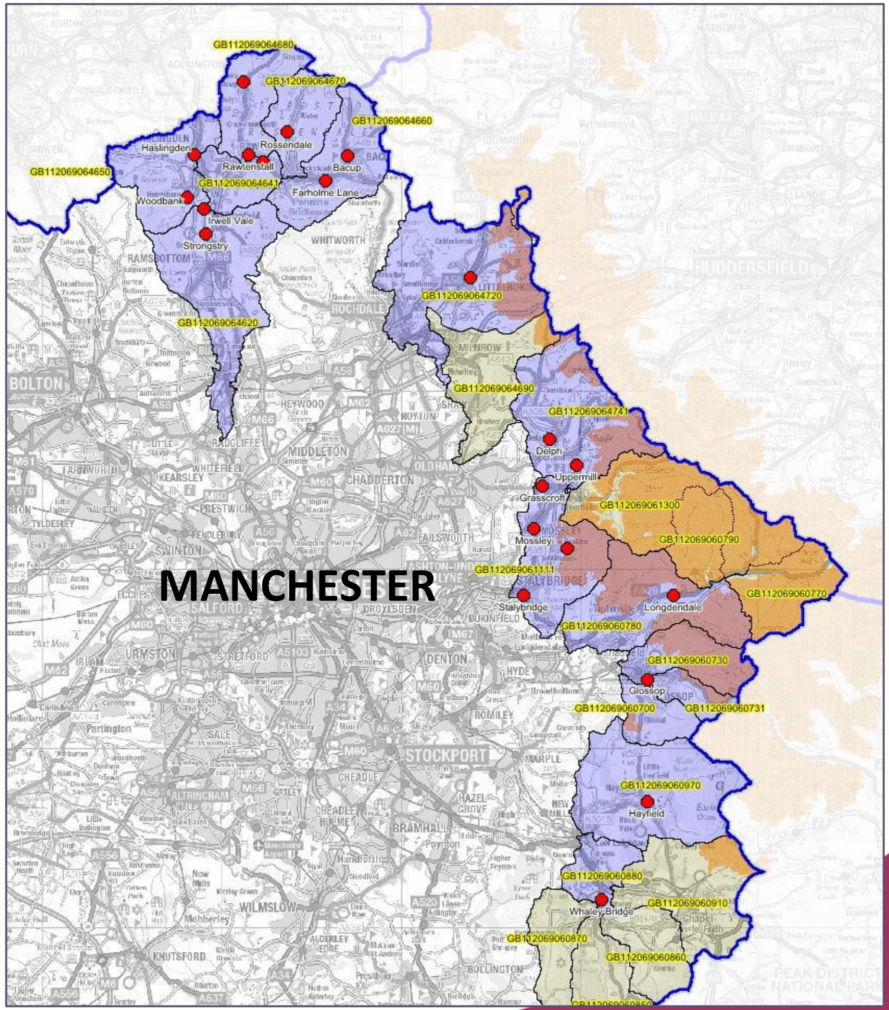
- A single case study
- Parameter set based on plot-scale studies
- Great confidence in model prediction would be provided by field observations at micro/small catchment scale

Review conclusions

- Recent research has significantly enhanced our understanding of hydrograph and peak flow responses to peatland restoration
- Increasingly robust evidence that restoration can reduce peak flows and contribute to NFM at small (<20 km^2) catchment scales
- Still significant uncertainties!
- Modelling approaches, informed and constrained by empirical studies, are available for fuller assessments at the scale of communities at risk and for events with different return periods
- Ongoing projects and modelling programmes (e.g. PROTECT, iCASP, Mires on the Moors) are addressing uncertainties and knowledge gaps

PROTECT-NFM Project

- Derive further **empirical evidence** of the impact of upland restoration and management techniques
- Use this new empirical evidence to **build a model** suitable for predicting the impact of NFM measures at large catchment scales
- **Apply the model** in headwater catchments draining to 22 C@R on the eastern edge of Greater Manchester
- **Collate data on existing restoration works** across the UK with NFM potential and available discharge data and to apply our modelling approaches
- Provide **practical and policy guidance** on the planning and implementation of headwater NFM applications relevant across the UK uplands



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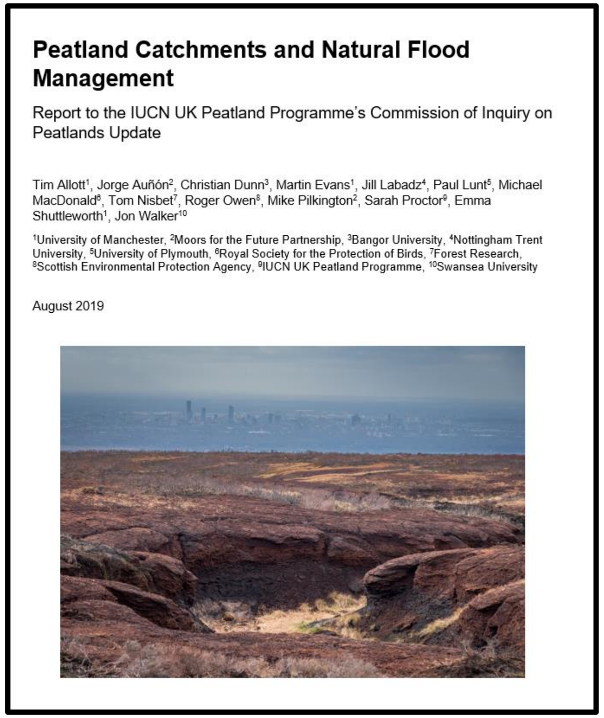
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IUCN Commission of Inquiry Technical Report on Peatland Catchments and NFM can be downloaded from the University of Manchester research portal or IUCN UK peatland programme website

https://www.research.manchester.ac.uk/portal/files/154873097/Allott_et_al_2019_IUCN_COI_Peatlands_and_NFM_FULL_REPORT.pdf

https://www.iucn-uk-peatlandprogramme.org/resources/commission-inquiry/commission-inquiry-peatlands-update-2017-20