



Natural Defences for Flooding

DO WE NEED TO ENGINEER OUR WAY OUT OF EVERYTHING?

UK – Winter 2020

- Rhondda Cynon Taf one of the worst hit regions of the UK
- >600 households affected
- >600 Business affected
- 7 bridges damaged
- Council – bill for >£30mill
- Storms Dennis, Ciara and Jorge in quick succession
- On 16th Feb - The Environment Agency issued 347 flood alerts, 282 flood warnings, the highest on record – followed by 7 severe flood warnings in England.



Wettest February on record and 5th wettest Winter

February 2020 has been the wettest February on record for UK, England, Wales and Northern Ireland, and the second wettest (behind February 1990) for Scotland. It has also been the fifth wettest of any calendar month in a series from 1862 behind only October 1903 (227mm), December 2015 (217mm), November 2009 (215mm), and December 1929 (213mm) (Met Office, 2020)



And what of future predictions?

“Extremely wet days during UK winters are currently up by around 15% compared with previous decades,” said Dann Mitchell of Bristol University’s Cabot Institute for the Environment. “Wetter future winters is a consistent projection with some predicting a 30% to 35% increase in rain by 2070. Our government and town planners need to invest significantly in UK flood defences.”



Are we prepared for that?

“We are simply not prepared for the flooding coming our way in future,” said Prof Hannah Cloke, of Reading University. “We need to carry out a complete overhaul of our defences and be prepared to spend a lot more on them over a longer period of time.”



Current Strategy Against Flooding

- Better early warning systems
- Modify homes to withstand floods
- Construct building above flood levels
- Install more flood barriers
- Tackle Climate Change
- Increase spending on flood defences
- Protect wetlands and plant trees strategically
- Restore rivers to their natural courses
- Introduce water storage areas
- Improve soil conditions

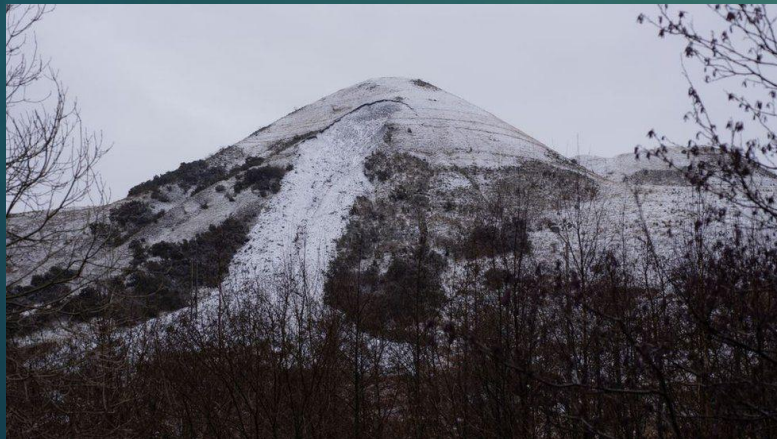


Welsh Government: new strategic approach

- ▶ National Strategy for Flood and Coastal Erosion Risk Management
- ▶ The Wales Flood Map
- ▶ Between 2016 and 2021 - £390 mill invested
- ▶ Further £4.4mill for recent flood damage
- ▶ National Strategy to incorporate Welsh legislation on the environment, wellbeing and sustainable drainage



Skewen, January 2021 - minewater

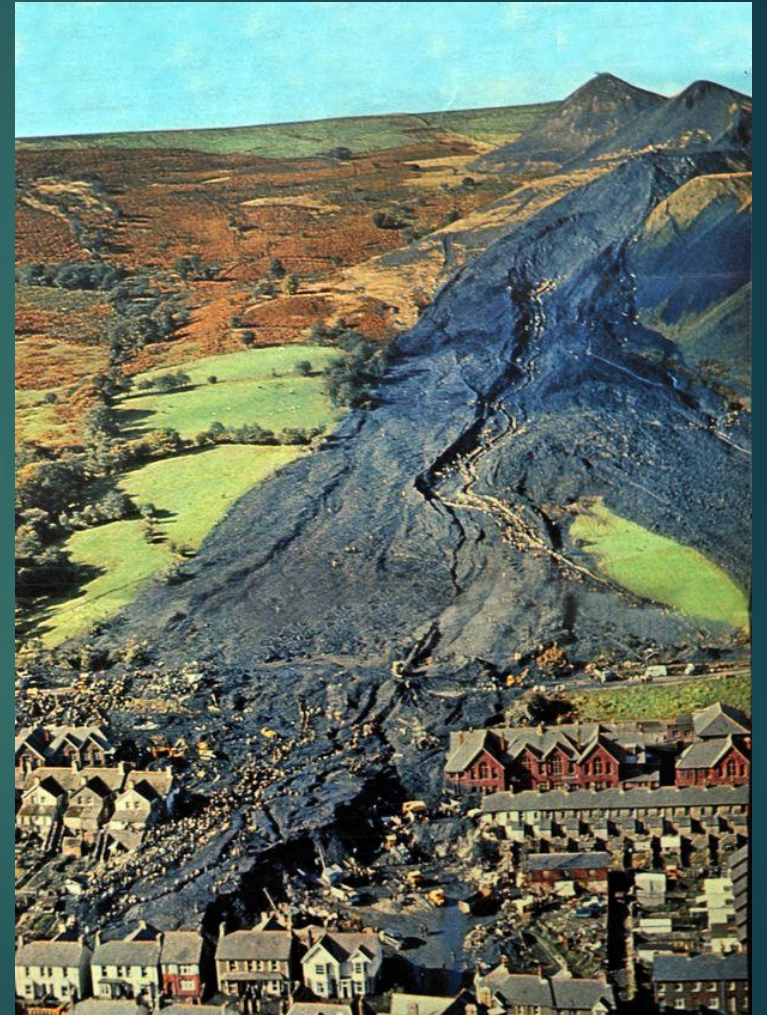


- 80 properties evacuated in Skewen – underground mineshaft
- Risk assessment in Wales reveals 300 coal tips classed as “high risk”
- Seventy are in Caerphilly, 64 in Rhondda Cynon Taf, 59 in Merthyr Tydfil, 42 in Bridgend, 35 in Neath Port Talbot, 16 in Blaenau Gwent and eight in Swansea.

Tylorstown, Rhondda (2020)

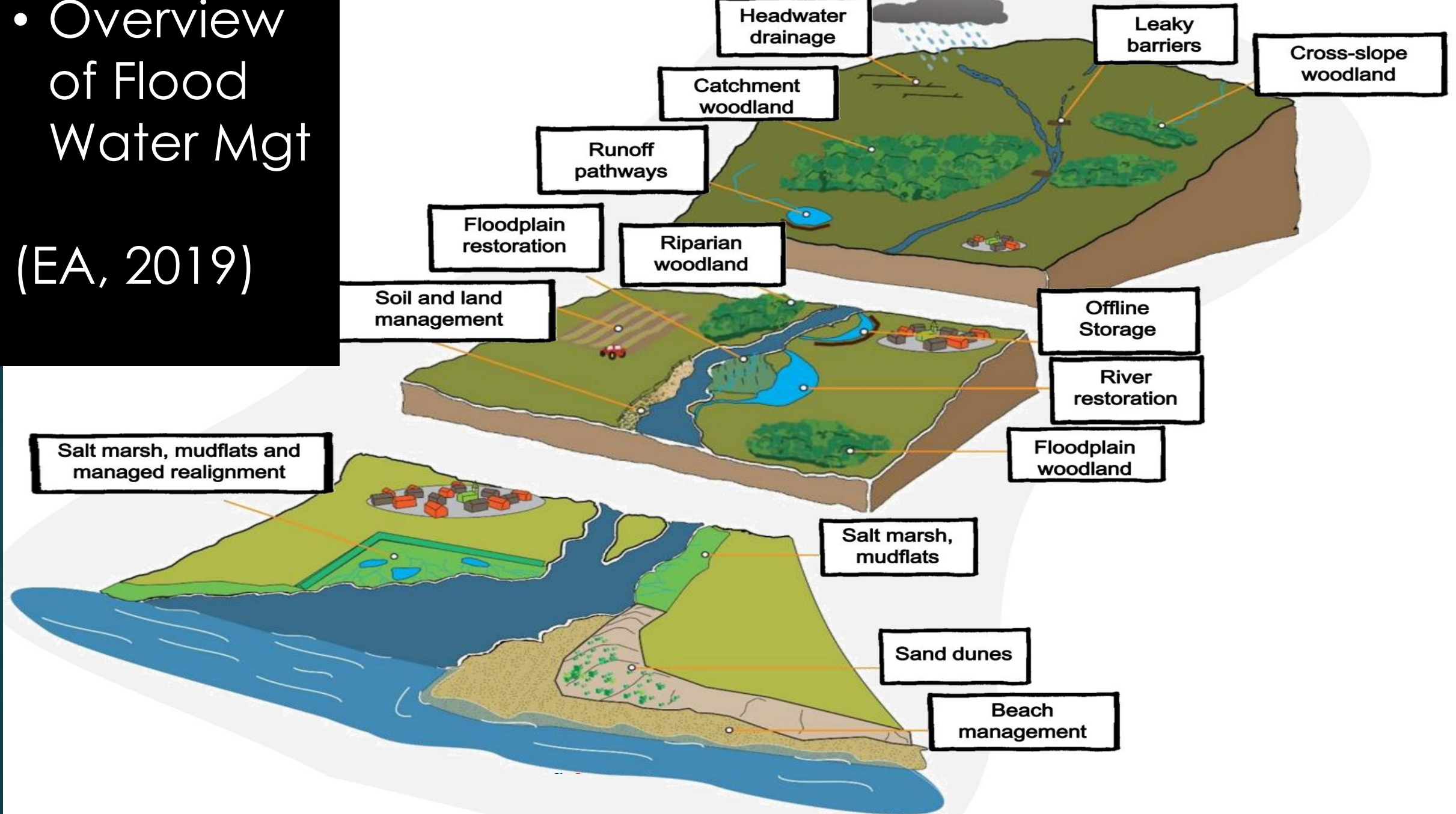


Brings back horrific memories of Aberfan



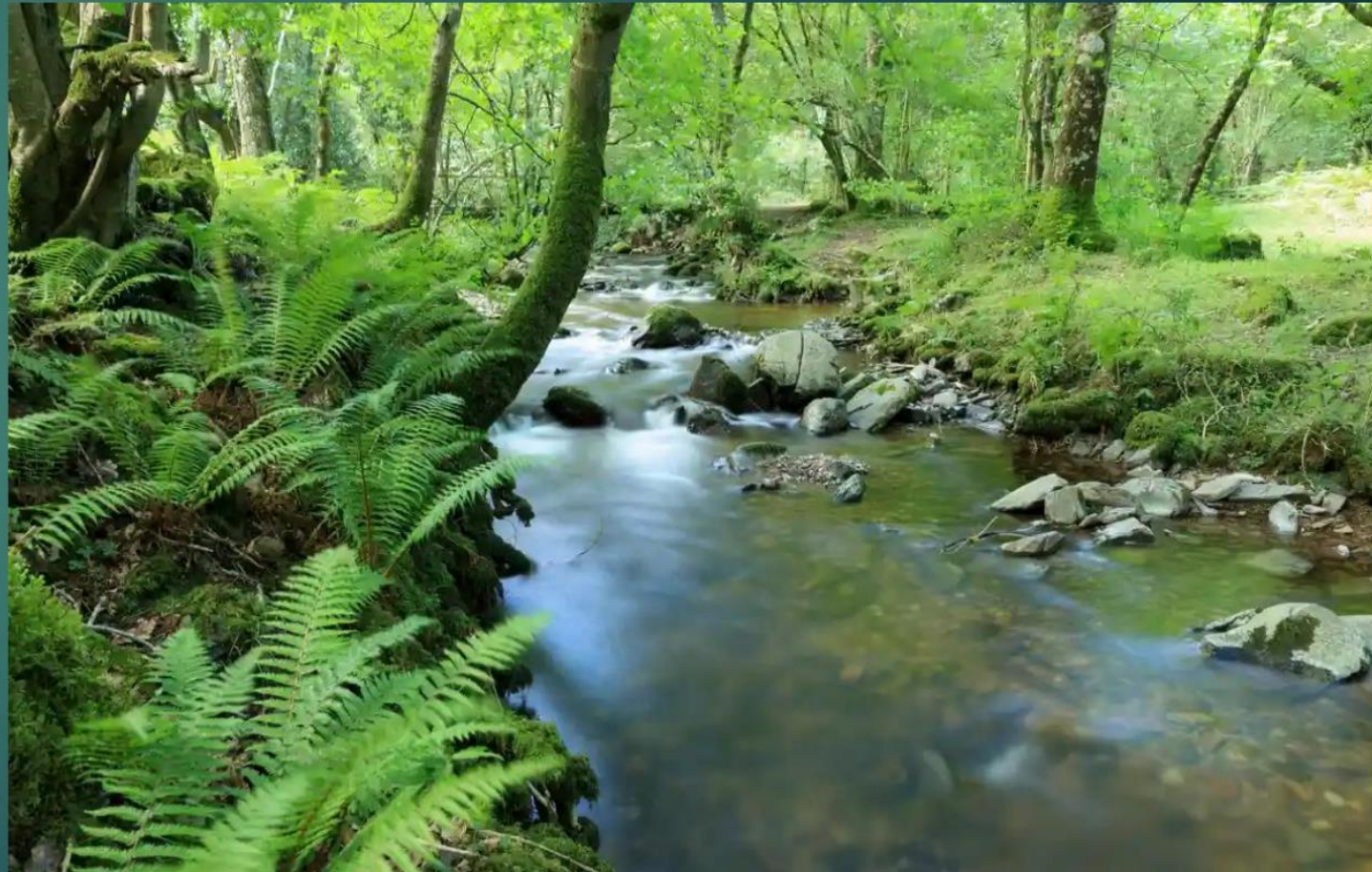
- Overview of Flood Water Mgt

(EA, 2019)



River Restoration

- Excavation of additional channels to allow a river to naturally meander rather than flowing through a single channel (Exmoor)
- In a 25 km² catchment in the New Forest the results of a monitoring study found river restoration led to a 21% reduction in flood peak and a 33% increase in peak travel for 2-year recurrence event (Sear et al, 2006).
- Allow for meandering routes:
 - Reduces peak flow
 - Slows velocity of water
 - Allows water storage



Beavers – natural engineers

- £13m project with focus on five key areas: the River Conwy in North Wales, the Derwent in Cumbria, the Upper Bure in Norfolk, the Bollin in Cheshire and Porlock Vale streams in Somerset.
- “Their presence in our river catchments is a sustainable way to help make our landscape more resilient to climate change and the extremes of weather it will bring.” (Ben Eardley, National Trust, 2018, p.2)



Natural engineers

- 5 year study in Devon on the River Otter
- Alleviated flooding (one family have built 6 dams upstream of the flood prone East Budleigh)
- Other benefits – ecotourism, reduced pollution, new wetlands benefited water voles, riverine birds such as dippers and wildfowl including teal.
- 37% more fish in pools created by beaver dams than in comparable stretches of river.
- Downside – can create farmland flooding
- Management is needed for stakeholder harmony



Leaky Barriers/dams

- Natural woody material laid in streams and ditches.
- Temporary hold the water back
- Encourage it to overspill to surrounding area and slow peak flow
- Store it in the landscape
- Intercept rainfall preventing it reaching the rivers in many cases
- Set above the normal stream/beck level, so normal flow and fish movement is not impeded.
- suited to smaller watercourses less than 2m wide
- Low cost and maintenance

(Eden River Trust, 2020)



Water Storage Areas

- ▶ Following the severe flooding of 2009 a £5.6 million flood alleviation scheme was established in Thacka Beck, on the outskirts of Penrith, Cumbria. More than 675 metres of culverts underneath the streets of Penrith were replaced and a 76,000m³ flood storage reservoir – the equivalent of 30 Olympic sized swimming pools – was constructed upstream to hold back flood water. The risk of flooding from the beck was reduced from a 20 per cent chance in any given year to a one per cent chance, according to Cumbria Wildlife Trust. (Grant, 2015)

Offline Storage

- ▶ Areas of land adapted for water storage containment for slow release at a later stage
- ▶ Use a bund; underground tanks
- ▶ Often Floodplains within the upper catchment area
- ▶ Wetlands and ponds can create space for wildlife also



Floodplain Restoration

- ▶ Restores the hydrological connectivity between the river and floodplain
- ▶ Encourages regular flood inundation and water storage
- ▶ Creating an extra 50ha of floodplain (Norfolk Broads) provides £1m of carbon sequestration benefits and £27m of recreational value over 100 years (Tinch et al., 2012).
- ▶ Ecosystem services



Saltmarsh restoration

reduce and dissipate wave and tidal energy in front of flood defences and can extend their design life.

Valued a habitat, climate regulation

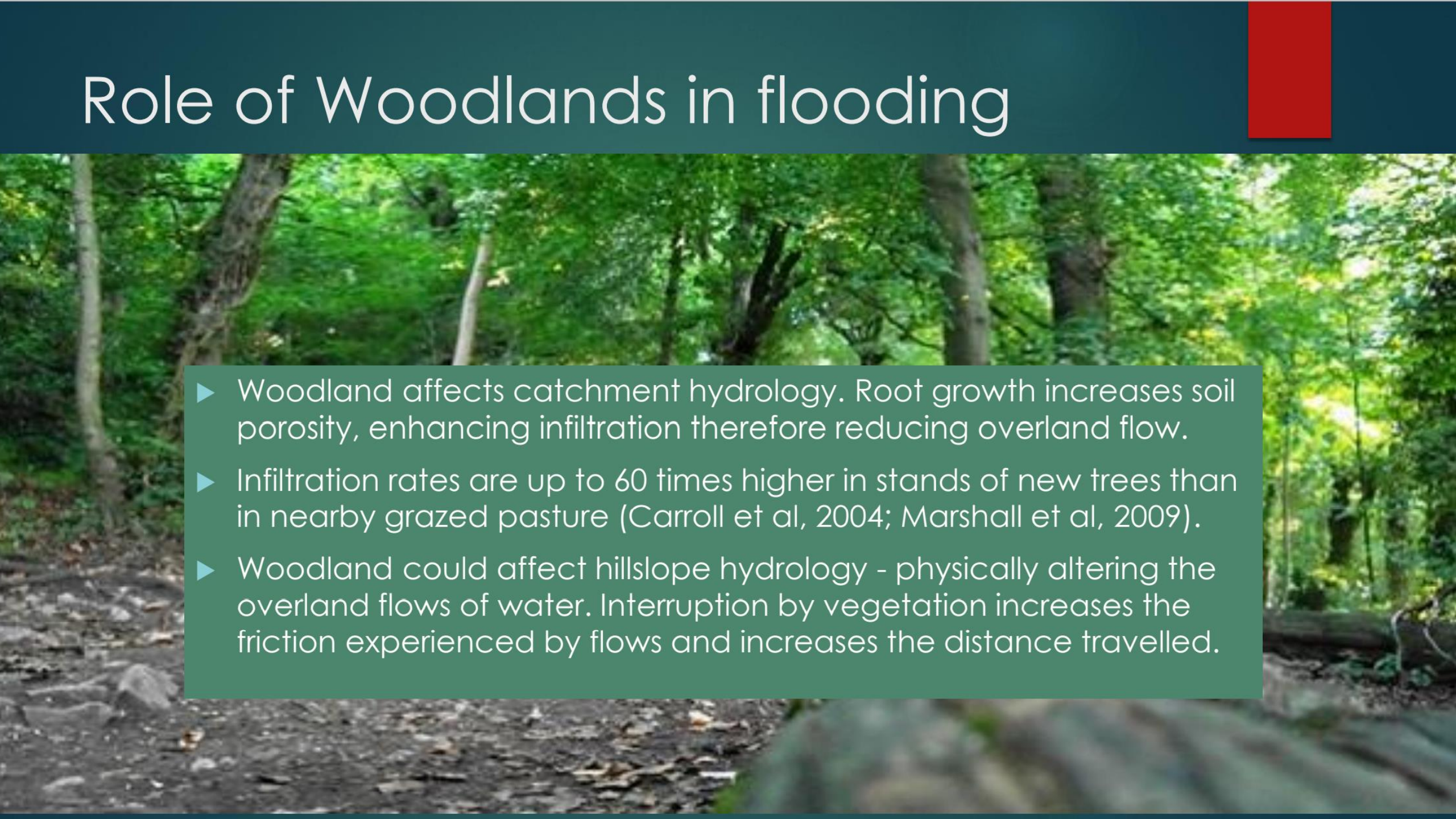
Cwm Ivy in Gower

Not planned but due to a seawall breach

Alleviated flood risk in other parts of Carmarthen Bay



Role of Woodlands in flooding

- 
- A photograph of a lush green woodland. In the foreground, there is a dark, rocky path. The background is filled with numerous trees with vibrant green foliage, creating a dense canopy. Sunlight filters through the leaves, creating dappled light on the ground.
- ▶ Woodland affects catchment hydrology. Root growth increases soil porosity, enhancing infiltration therefore reducing overland flow.
 - ▶ Infiltration rates are up to 60 times higher in stands of new trees than in nearby grazed pasture (Carroll et al, 2004; Marshall et al, 2009).
 - ▶ Woodland could affect hillslope hydrology - physically altering the overland flows of water. Interruption by vegetation increases the friction experienced by flows and increases the distance travelled.

Catchment Woodlands

- Intercepts, slows, stores and filters waters
- A study in New Zealand demonstrated that 67% catchment afforestation reduced mean flood peaks 55-65% across three different flood peaks (Fahey & Jackson, 1997).
- Carbon sink – climate change
- Biodiversity benefits



Riparian Woodland

- Woodlands found alongside rivers, lakes and streams
- Root stabilise river bank reducing erosion and siltation
- Trap sediment and slow water flow
- High evaporation losses and can store water – below ground storage
- Multiple ecological benefits through shading and nitrate removal
- One study found that riparian vegetation removed more than 20% of nitrates than the channelised river section (Peter *et al.*, 2012)



Soil and land management

- ▶ Encouraging better infiltration
- ▶ Slowing and storing surface water run-off
 - ▶ Agriculture – soil aeration, conservation tillage, crop rotation, stock density; hedgerow management and buffer strips
 - ▶ Conversion of arable land to grassland – carbon capture
 - ▶ Peatland management



Downstream Catchments

- Cities have a role to play too
- Adherence to policy
- Planners and Local Authority responsibility
- Innovation construction methods



Urban areas

- ▶ Sustainable drainage systems
- ▶ The Stroud rural sustainable drainage system (or SuDS for short) project aims to help reduce the risk of flooding to around 112 properties by introducing a large number of small-scale measures in the upper catchment aimed at slowing peak flood flows. Over 250 structures have been built so far, including leaky woody dams, culverts with soak-aways, field bunds and dry ponds.
- ▶ Green infrastructure – green roof, green walls, swales, permeable pavements



UK's Current Peatland Health

- At least 80 per cent of UK peatlands are damaged by drainage, heavy grazing, regular burning, cultivation, forestry or other management.
- It can take over 1000yrs to generate 1m of peat
- 28 mil tonnes C stored in Lake District alone
- 5% loss of UK peat soils = annual man-made C emissions



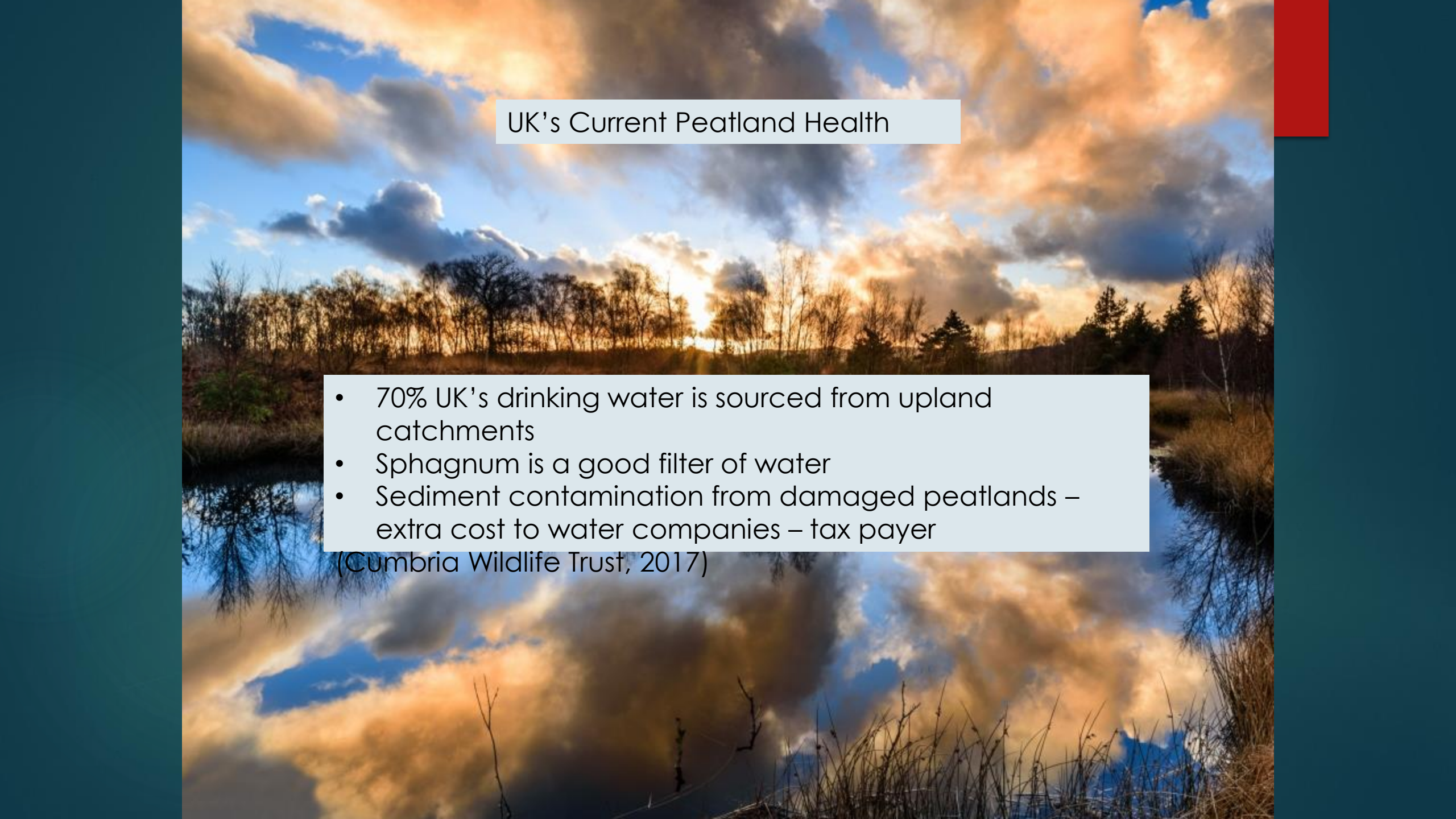
Peat cutting for fuel

- ▶ No specific laws to prohibit such measures
- ▶ EU Habitats and Irish legislation banning the practice
- ▶ 53 bogs in Ireland designated as SACs
- ▶ 40% Ireland's bogs destroyed between 1995 and 2012 alone (Flemming, 2013)



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UK's Current Peatland Health

- 70% UK's drinking water is sourced from upland catchments
- Sphagnum is a good filter of water
- Sediment contamination from damaged peatlands – extra cost to water companies – tax payer

(Cumbria Wildlife Trust, 2017)

PEATLANDS

Peatlands cover 12% of the UK and their restoration has never been a more pressing issue - unfortunately, 80% are in a poor condition because they've been drained of water or damaged by extraction.

The IUCN UK Peatland Programme has issued a call for one million hectares, a third of UK peatlands, to be in good condition or under restoration management by 2020.

Table 3 UK Peatland Strategy

AIM
To provide a long-term framework for the conservation, restoration and sustainable management of UK peatlands using good practice methods across all three main peatland types, blanket bogs, lowland raised bogs and fens, in order to secure multiple benefits from enhanced biodiversity, water quality, water regulation, climate mitigation, cultural services and resilience in the face of climate change.

GOALS	OBJECTIVES	OUTCOMES Timescales (2017-2040)	MILESTONES
A. Conserve and enhance through restoration, the best and most readily recoverable peatlands Early conservation avoids expensive investments needed and greater risks of failure associated with repair of more severely degraded areas. Restore mire vegetation communities to areas where past management has resulted in a shift to other vegetation communities (e.g. heath)	1. Bring about the long-term protection, enhancement and sustainable management of peatlands in areas that support i. semi-natural mire plant communities and ii. other semi-natural vegetation on peat soils (e.g. heath and low production forest plantations) through: a) Maintaining and enhancing a suite of local, national and international level of protected areas for biodiversity alongside wider measures to ensure the favourable status of peatland habitats and species across their range. b) Conserving functional ecosystem units as the building blocks for habitat networks. c) Preventing damage from development and land management. d) Ensure the full long-term costs of potentially damaging activity is properly taken into account in decision making process	[95%] of UK peatlands supporting semi-natural vegetation are under favourable management for their peatland biodiversity and ecosystem functions Local, national and international protected area status confirmed for all qualifying peatlands (including World Heritage sites, Ramsar and EU Habitats Directives) and all sites under favourable condition. Cost savings are being made through avoiding the need for major interventions. Policies are in place for peatland protection and restoration in new developments and land management change. Environmental assessment processes are designed to assess full costs to carbon, water and biodiversity.	2020 Meet the IUCN UK Peatland Programme challenge: 1 million hectares of peatland in good condition, under restoration agreements and being sustainably managed Establish the current baseline and begin to define management plans 2030 50% of the peatland resource is conserved in favourable condition. 2040 Target [95%] is achieved.

Types of peatland:

- Blanket Bog
- Lowland raised mire
- Valley mire





Analogy used by IUCN (2016) is that of a patient arriving at A&E:

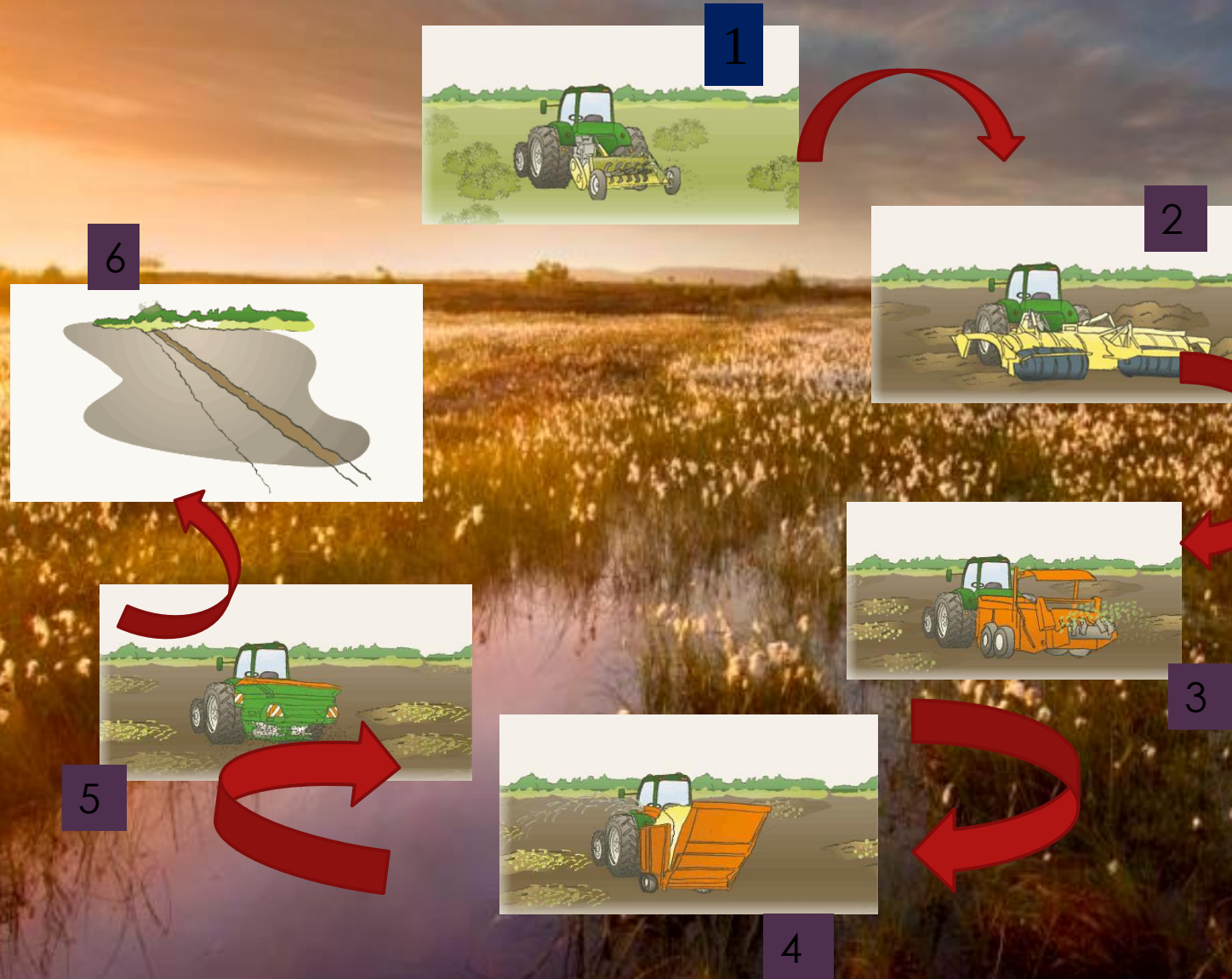
1. Assess the patient
2. Stabilise condition
3. Long-term healing & recovery plan



STEPS TO PEAT RESTORATION

- Re-establishment of typical peatland plant cover
- Hydrological regime
- Collecting donor seeds, vegetation

The textbook mechanical way





Stabilisation is the over-riding priority to prevent further erosion of peat and greenhouse gas emissions

Raise water table

Exclude oxygen and prevent decomposition

Repair vegetation layer

As long as there is water loss and the system lacks a peat-forming vegetation, the peat bog has not been stabilised and its condition will continue to deteriorate

Recovery Phase

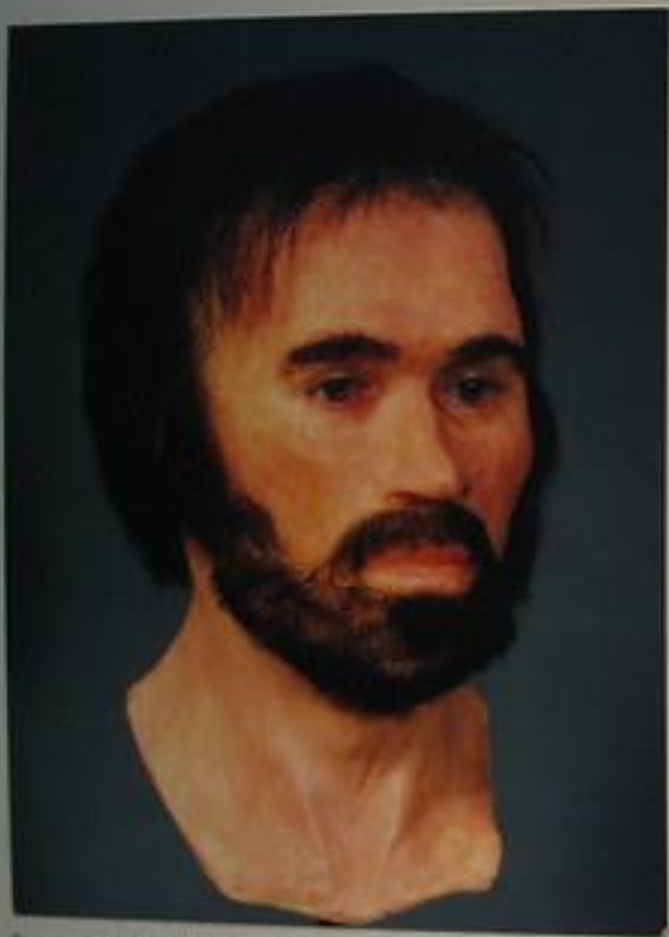
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- A yellow excavator is positioned on a peatland landscape, working on the ground. The landscape is covered in low-lying vegetation, and the background shows rolling hills under a blue sky with white clouds. The excavator is a small yellow machine with a long arm, positioned in the middle ground of the landscape.
- ▶ The fundamental process of recovery is performed by the peatland system itself.
 - ▶ Restoration management should therefore be focused - enabling the recovery process to occur speedily cost effective
 - ▶ Concept of time
 - ▶ Pressure to see results by funding body

The lost Archives



- ▶ Peat restoration is important for environmental reasons but what of anthropology and history?
- ▶ Plant, insect and microbial remnants in peat – historical record of landscape changes
- ▶ How past natural systems responded to climate changes

Lindow Man



Reconstruction of the head, the face, beard and mustache had been bleached by the action of acid peat-water
Reconstructed by William Starna, Manchester University

Lindow Man is the name given to a human body found in a peat-bog at Lindow Moss, near Manchester, in 1985. After a leg was discovered by workmen sorting peat, archaeologists were called in and the upper part of the body was found, still in the ground. It was boxed and transported to the British Museum, where it was carefully excavated and thoroughly examined by a large team of scientists.

When he met an horrific death, sometime in the middle of the first century AD, Lindow Man was about 25 years old. Stunned by a couple of blows to the head, he was then garotted, his throat was cut and he was bled, before being placed in a pool in the bog. This elaborate sequence of events strongly suggests that Lindow Man was a ritual sacrifice, and it may be no coincidence that shortly before his death he had had a drink including mistletoe - the pollen was still in his stomach. Mistletoe was sacred to the Druids, and it is recorded that Druids carried out human sacrifices. At least one other contemporary body was found in the same bog.

MoorLIFE 2020 Project

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- A wide-angle photograph of a peat bog landscape. In the foreground, there is a field of tall, dry grass and some purple heather. A yellow excavator is visible in the middle ground, working on the peat. The background shows rolling hills under a blue sky with white clouds. A red vertical bar is on the right side of the image.
- ▶ Stabilising and revegetating 95 square km of bare peat
 - ▶ Installing 15,000 mini-dams in drainage channels to help rewet the blanket bog
 - ▶ Tackling areas of over-dominant plant species, like heather,
 - ▶ Planting approximately 1.7 million plug plants of sphagnum moss
 - ▶ Controlling invasive species, like rhododendron and sitka spruce
 - ▶ Working with land managers to share best practice

Peak District National Park – reintroduction of sphagnum mosses

- The £1.25 million investment from various Natural England and the EU LIFE programme through the partnership's MoorLIFE 2020 project.

“Sphagnum mosses are amazing plants that are able to hold between 10 and 20 times their weight in water.....play a major role in keeping water on the hills for longer, reducing the risk of wildfires and of flooding downstream”. (Buckler, 2016)

FLOOD PREVENTION

- ▶ Water running over Sphagnum on blanket peatlands moves much more slowly (iCASP, 2008; IUCN, 2019)
- ▶ Water movement dominated by flow close to the surface
- ▶ Sediment released from bare peat strongly influences peatland stream ecosystems affecting both their biodiversity and functioning.



Making Space for Water Project

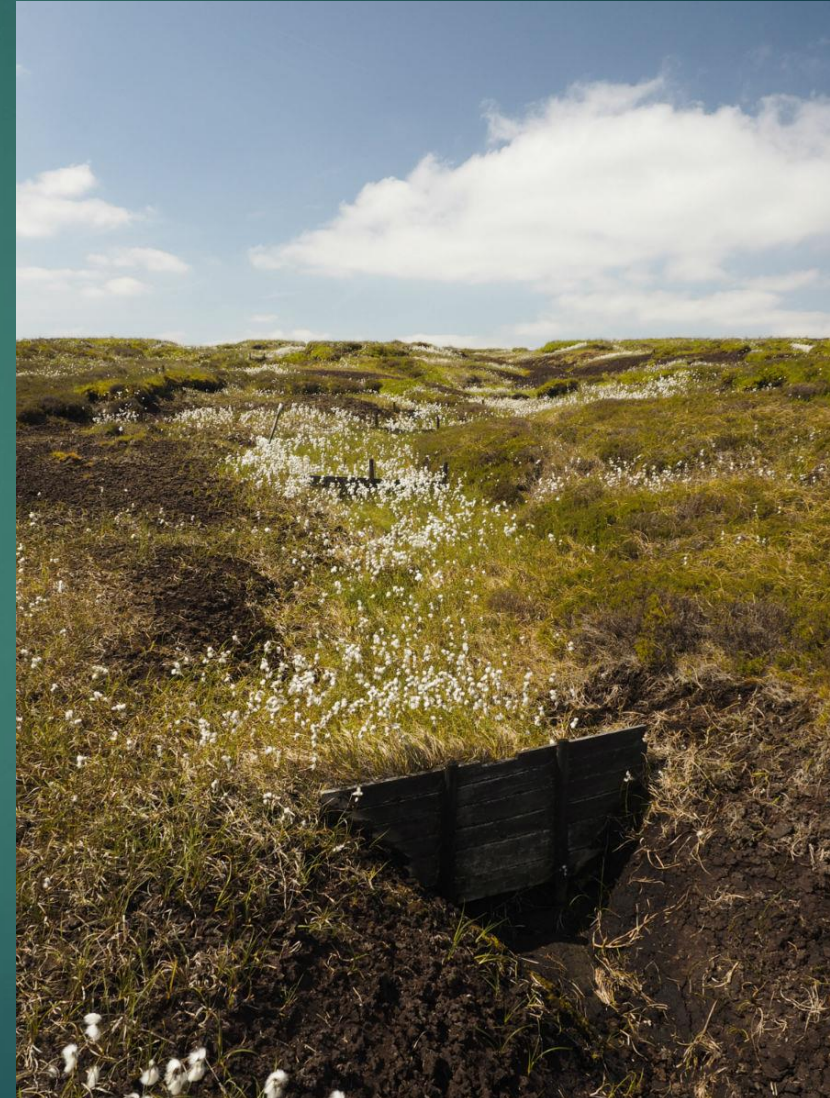
- ▶ Defra funded
- ▶ Project to monitor local flood risk on the Kinder Scout plateau
- ▶ Project 2012-2015
- ▶ Monitored:
 - ▶ Rainfall volumes in mini catchments
 - ▶ Volume flowing out of catchments
 - ▶ Height of water table below surface
 - ▶ Quantity of peat and carbon washed away
 - ▶ Colour of water
 - ▶ Control plot left



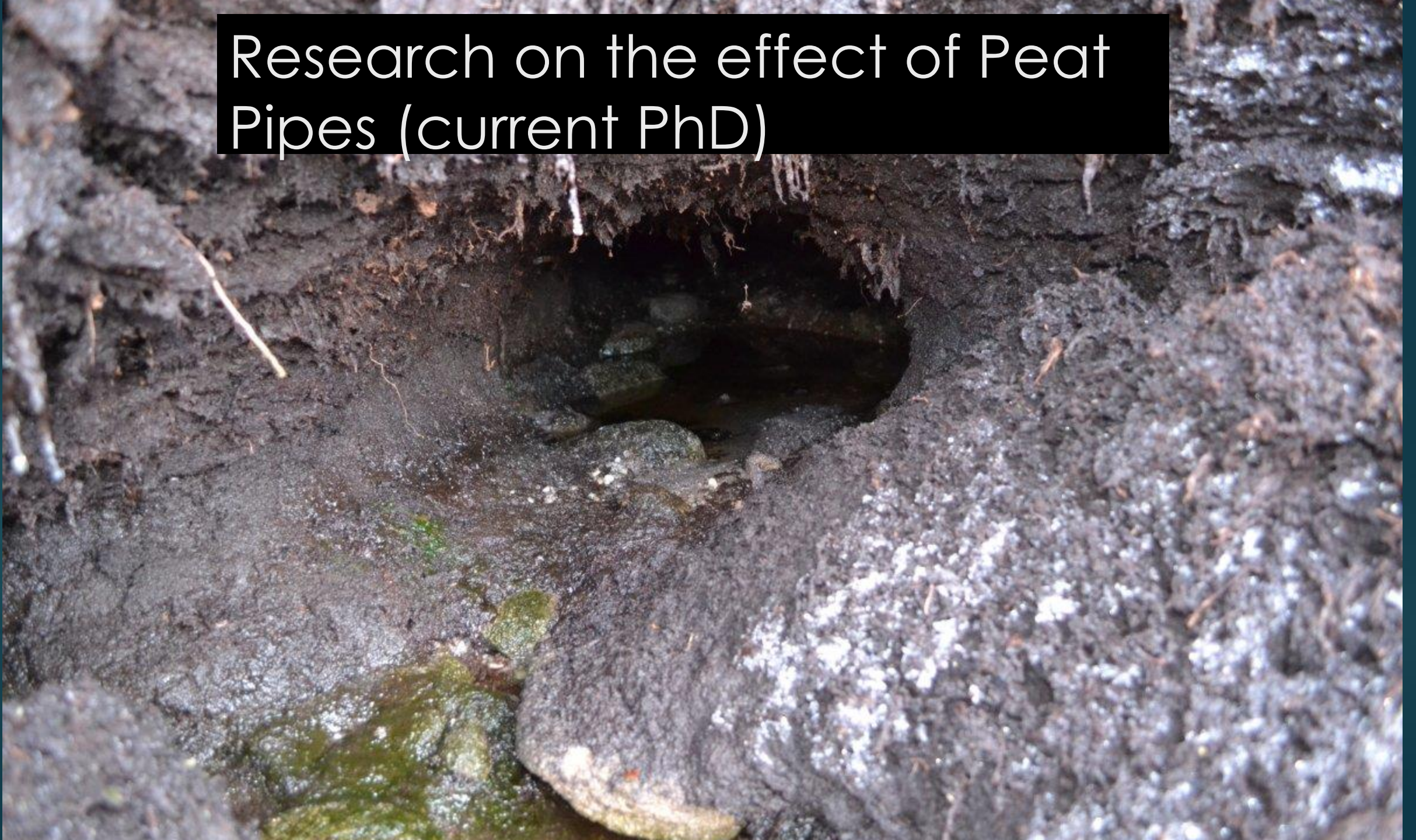
Kinder Catchment Monitoring Project, 2015

- ▶ peat accumulation or water pooling associated with 95% of gully blocks
- ▶ upstream vegetation establishment associated with 94% of gully blocks
- ▶ 'nurse' grasses dominating vegetation cover
- ▶ mosses and Lichens cover increased significantly
- ▶ 39 new locations of either single plants or carpets of sphagnum
- ▶ bare peat was reduced by 75% where work was carried out
- ▶ gradual rise in the water table, and reduced water flow after heavy rain

(MoorLIFE Project; 2015; IUCN, 2019)



Research on the effect of Peat Pipes (current PhD)



Peat Pipes.... tbc

- ▶ Underground channel – a conduit for water beneath the peat
- ▶ How?
- ▶ Why?
- ▶ What effect on the peatlands
- ▶ Finding them is a challenge



CARBON SINK

- ▶ Peatlands – largest store of carbon in UK
- ▶ Bare peat has the potential to lose more than 500 tonnes of carbon per square kilometre, per year.