Mires Monitoring Results

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Project partners:

1 INTRODUCTION

The peatlands of Exmoor and Dartmoor are important locally and nationally, for several reasons. They are a large and long term carbon (C) store, they store and provide drinking water and support rare habitats. Unfortunately, their unique position at the southern and western limit of where conditions are appropriate for peatlands to form makes them highly vulnerable to climate change. Future precipitation and temperature change might prevent peat accumulation and even put them at risk of disappearing.

The vulnerability of the peatlands of Exmoor and Dartmoor has been further increased by the anthropogenic pressures upon these landscapes, including drainage, peat-cutting, grazing and burning activities. Such activities have left peatlands in the south west vulnerable to erosion and have altered their ecohydrology (i.e. the interplay between ecological and hydrological structure and function).

In an attempt to restore these peatlands to more natural hydrological behaviour, and promote a suite of associated ecosystem services, the Exmoor and Dartmoor Mires-on-the-Moors projects were initiated in 1998 and 2010 respectively. In 2010, these projects became part of South West Water's catchment management initiative, Upstream Thinking. Between 2010 and 2015, the Exmoor Mires Project restored 1,130 ha of drained shallow peatland by ditch blocking (Figure 1), whilst the Dartmoor Mires Project focused on a pilot study restoring ca. 100 ha of deep peatland (Figure 2).

Evaluating the impact of such extensive restoration on the peatland's behaviour and functioning was an essential step as a proof of concept. This also gives us a better understanding of the functioning of the peatlands in the South West in order to better manage and protect them.

Figure 1 Exmoor pre- (left) and during restoration (right) Photo credit: Mires project, University of Exeter.

Figure 2 Photographs of Flat Tor Pan pre- (left) and post-restoration (right). Photo credit: Mires project, University of Exeter.

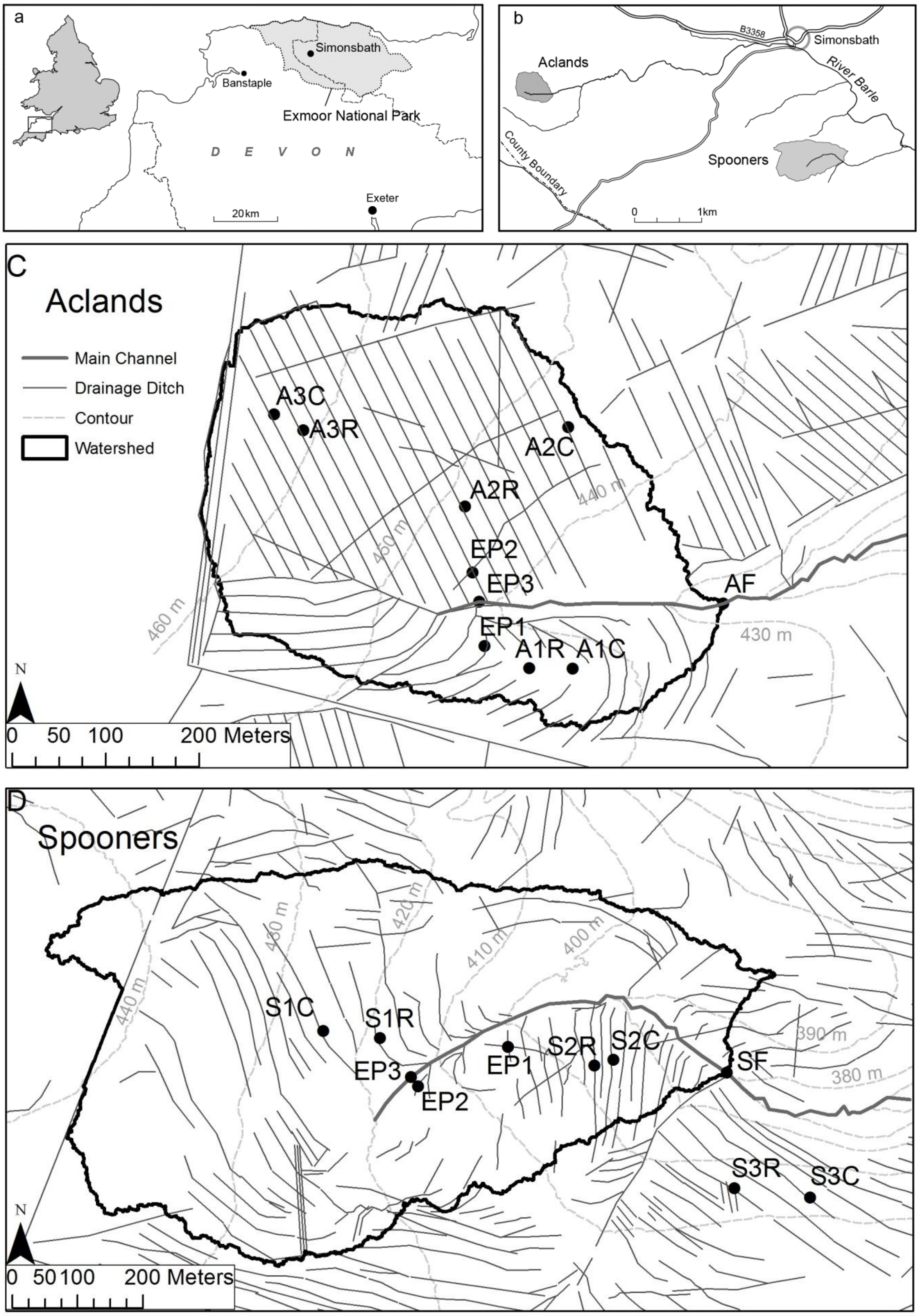
2 STUDY SITES

2.1 Exmoor

Aclands and Spooners are two small headwater catchments of the River Barle within Exmoor National Park, UK (51°9'N; 3°34'W) (Figure 3). These catchments are 4 km apart and are taken to be representative of the general peatland conditions found in the area. Altitude ranges between 380 to 450 m above sea level, with a 30 year average daily temperature of 10-12°C and 4.5-5.5°C for summer and winter respectively, and an average annual precipitation between 1800 and 2600 mm yr^{-1} (Met Office, 2012). Peat depths on Exmoor are shallow, on average ca. 33 cm (Bowes, 2006), but surveys in these catchments have shown that peat depths frequently range between 50 cm and 1 m (Smith, 2010). The vegetation comprises numerous mire and wet heath communities, such as *Sphagnum* spp. and *Eriophorum* spp., but *Molinia caerulea* (Purple Moor Grass) is by far the most extensive (Drewit and Manley, 1997). The area is characterised by very little bare peat, but has been heavily damaged by intensive drainage for agricultural reclamation during the 19^{th} and 20^{th} century. This drainage has left a very dense network of small ditches (about 0.5 m wide by 0.5 m deep) located approximately every 20 m, in a herringbone pattern. Peat cutting by hand has also been practised on Exmoor since medieval times, and features indicate that large amounts of peat have been removed for domestic use (Riley, 2014). Spooners and Aclands were restored, by ditch blocking with peat dams, in spring 2013 and 2014 respectively (Table 1).

Table 1

	Aclands	Spooners	Dartmoor
Date Equipment Installed	Winter 2010/11	Winter 2010/11	February/March 2012
Monitoring Commenced	March 2011	March 2011	April 2012
Pre-Restoration Monitoring Duration	March 2011 – April 2014	March 2011 - April 2013	April 2012 – July 2014
Restoration Dates	April 2014	April 2013	August 2014
Post-restoration Monitoring Duration	May 2014-ongoing	May 2013- ongoing	September 2014 - ongoing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Simonsbath
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b
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C
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Main Channel
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Watershed
A3C
A3R
A2C
A2R
440 m
450 m
EP2
EP3
AF
460 m
EP1
A1R
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Figure 3 Location of Exmoor National Park within the southwets fo England (a). Location of Aclands and Spooners catchments within Exmoor National Park (b). Location of experimental pools, flumes and CO_2 monitoring sites within Aclands (c) and Spooners (d) catchments.

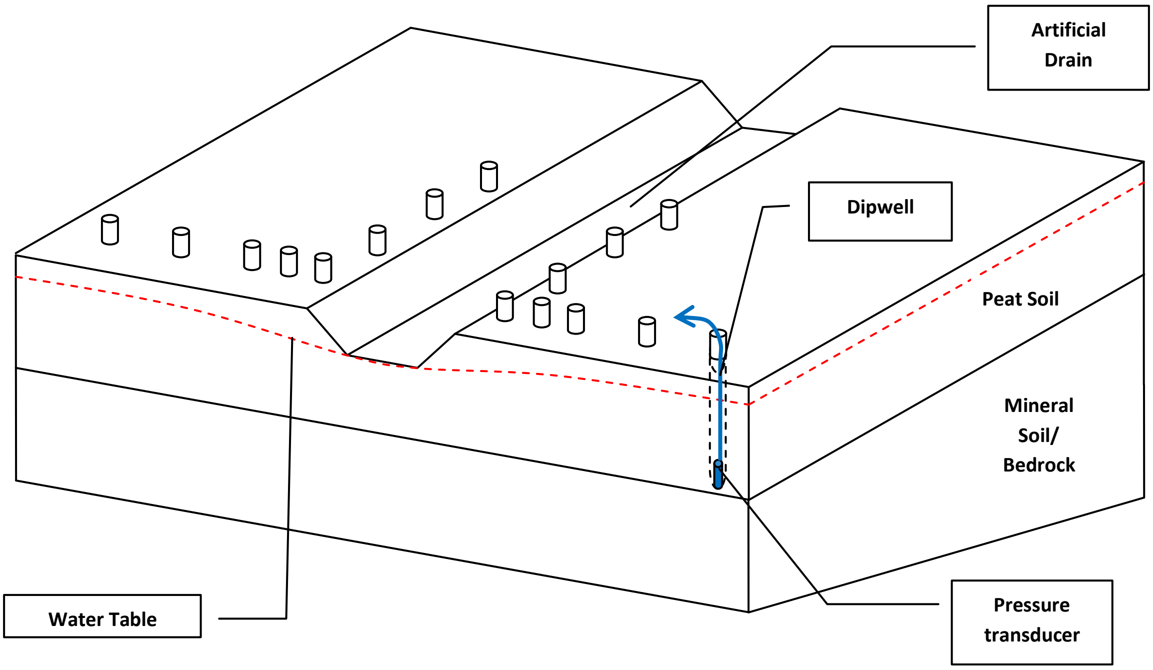

Figure 4 Design of experimental pools dipwell arrays. Conceptual design locating mini piezometers (dipwells) distributed along two axes adjacent to an anthropogenic drainage feature. The blue arrow represents the wired connection of each dipwell to the telemetry system.

2.2 Dartmoor

Flat Tor Pan is located in an area of degraded blanket bog on the north moor in Dartmoor National Park (49°51'N; 7°12'W) in the south west of England (Figure 5). On Dartmoor extensive areas of blanket bog have a pattern of erosional peat pans (generally <1 m deep) between vegetated peat blocks (haggs). Where the gradient is steeper, these peat pans form dendritic erosional features. The site lies at 515 m above sea level and the vegetation is classified as National Vegetation Classification class M17 *Scirpus cespitosus-Eriophorum vaginatum* blanket mire (Rodwell, 1991). The peat is a minimum of 2.5 m thick. Parry (2011) found a maximum peat depth of 3.29 m on Dartmoor and an average thickness of 0.807 m for blanket peat. Average monthly daytime temperatures ranged from a minimum of 1.5 °C in March 2013 to a maximum of 17.6 °C in July 2013. Daily total rainfall averaged 6 mm with a maximum of 83 mm on 23/12/2013. Restoration occurred in August and September 2014 (Table 1).

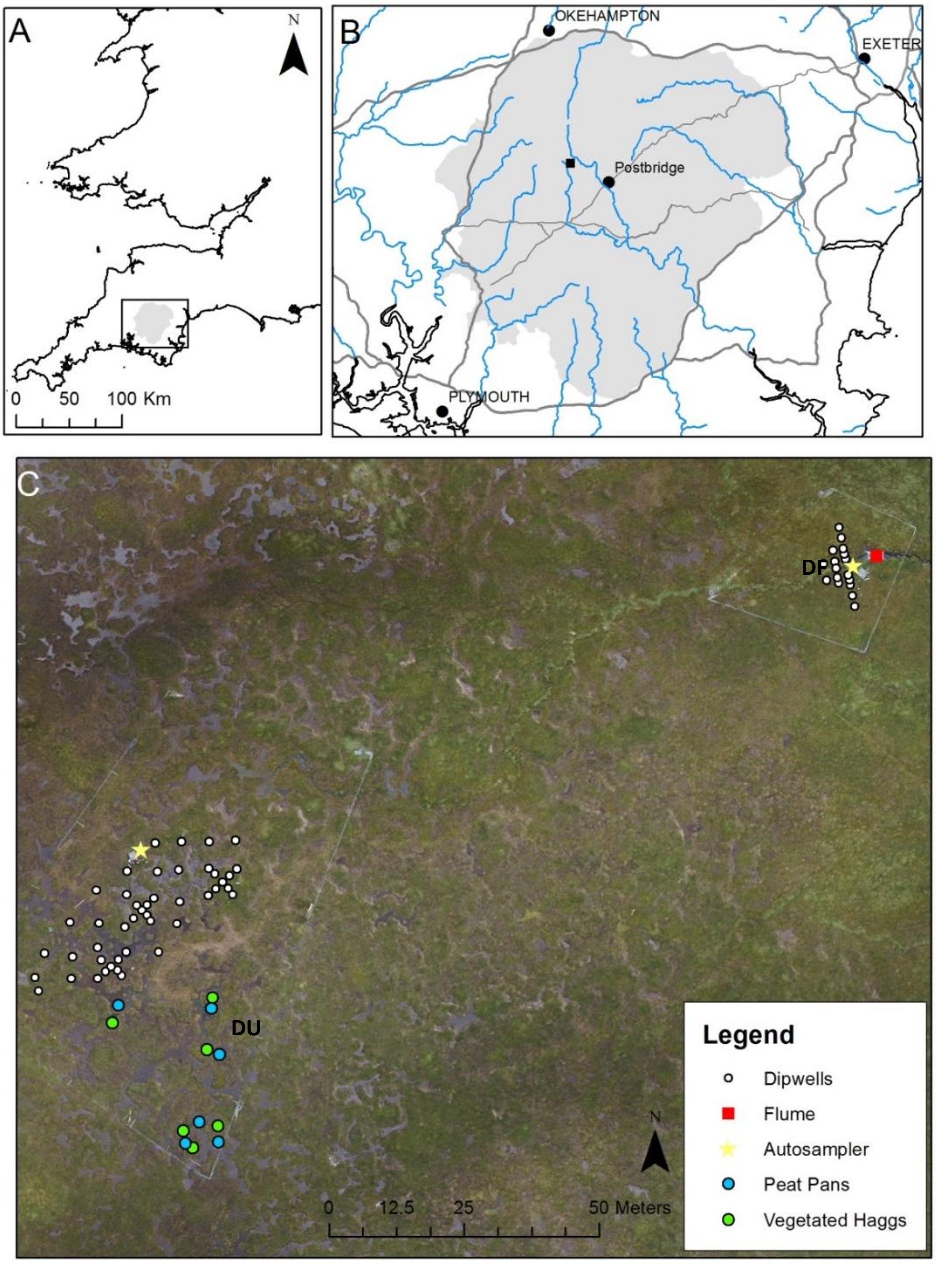

Figure 5 Location of Dartmoor National Park (shaded area) within the south west of England (a). Location of Flat Tor Pan study area within Dartmoor National Park, major roads and rivers marked (b) and layout of equipment within study site on Flat Tor Pan, with DU referring to Dartmoor Upper EP, and DF to Dartmoor Flume (c).

3 THE EFFECTS OF PEATLAND RESTORATION ON WATER STORAGE AND CHANNEL FLOW

3.1 Background

Upland blanket peatlands, such as those found across Exmoor and Dartmoor, form over large areas where precipitation and temperature are sufficient to keep the soil saturated for much of the year, preventing decomposition. How these ecosystems function is therefore intrinsically linked to this unique hydrological regime and how the system holds onto and releases water under varying conditions. Understanding how these peatlands respond to management interventions such as drain blocking, is therefore critical for those managing these landscapes, and protecting them into the future.

3.2 Why is this research important?

It is recognised that intact upland peatland landscapes provide many important ecosystem services. Because they are such specific, waterlogged environments, most of the ecosystem services valued from peatlands, e.g. the support of biodiversity, carbon storage and water quality improvements, rely on a high water table (Wilson et al., 2010). Consequently, understanding how drainage and erosion affect the storage and loss of water from these systems is critical in order to evaluate how restoration or management interventions may alter ecosystem services provided in the future.

3.3 Research Questions

This research will allow us to understand how damaged peatlands function across the South West of the UK, and how such systems are affected by restoration through rewetting work. As these peatland landscapes are characterised by both linear (e.g drainage, as shown on Figure 6) and dendritic patterns of damage (Figure 7), the research questions consider these separately:

1. How does linear anthropogenic drainage (Figure 6) affect water table depth (i.e. storage) and catchment runoff (i.e. water loss)?
2. How do erosional dendritic channels (Figure 7) affect water table depth (i.e. storage) and catchment runoff (i.e. water loss)?
3. How does restoration affect the water table and runoff dynamics across these types of ecosystem damage?

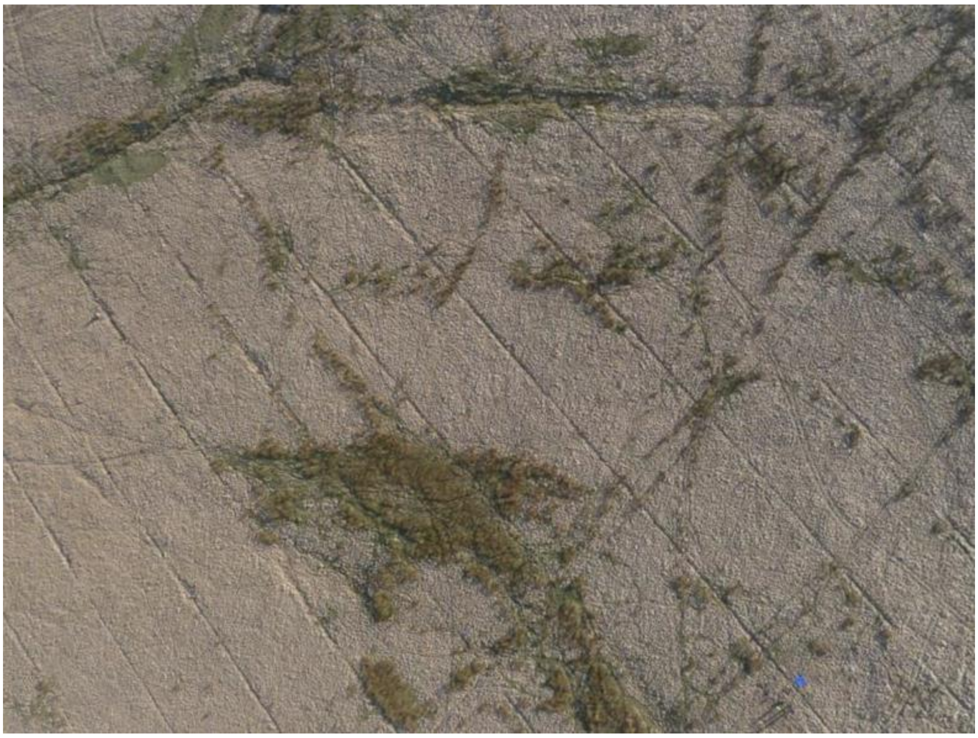

Figure 6 Linear anthropogenic drainage on Exmoor (Aclands).

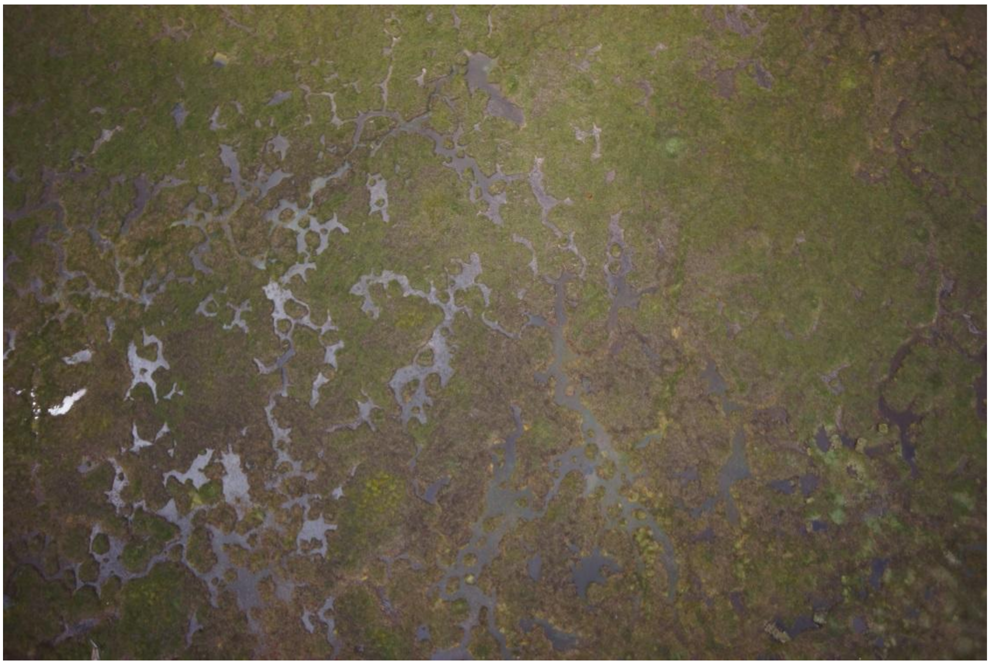

Figure 7 Dendritic/erosional degradation on Dartmoor (Flat Tor Pan).

3.4 Results so far

3.4.1 Exmoor

- Prior to restoration, these catchments were losing water (runoff) in a rapid, flashy manner.
- Lag times between peak rainfall and peak discharge were short, commonly between 1 and 1:45 hours across all monitoring locations (standard deviation = 3:10 to 8:39).
- Peak flows (Qp) from the catchment (per unit rainfall) are seen to be significantly lower following drain blocking (Figure 8), reducing the effect on downstream water discharge.
- Similarly, the total discharge (Qt) from the rainfall-runoff events (per unit rainfall), is seen to decrease following restoration. However, this fall is only statistically significant in the Aclands catchment.

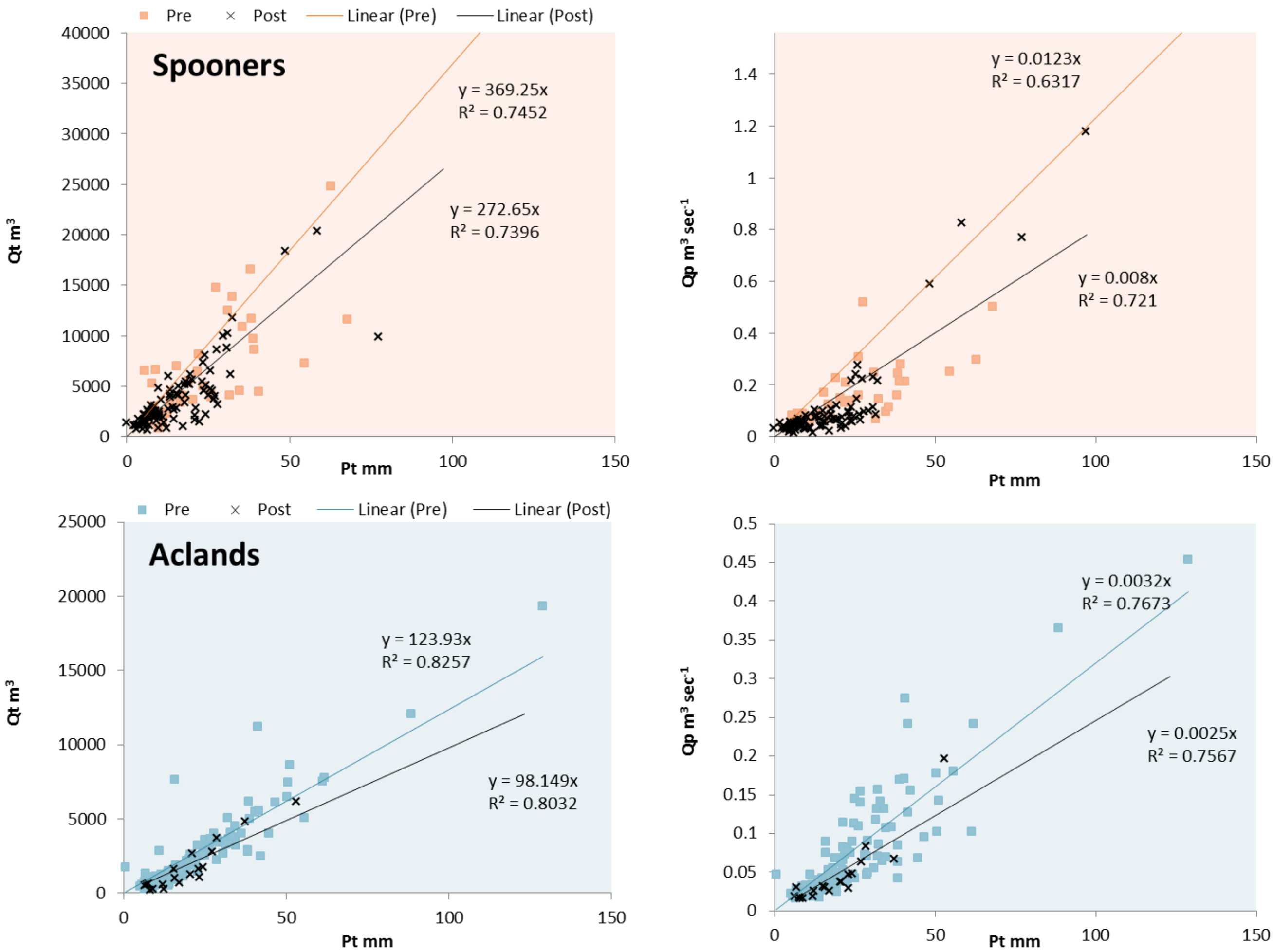

Figure 8 Total event rainfall (Pt) measurements versus total event flow parameters for all monitored rainfall runoff events and across all scales of monitoring. Discharge from the catchments as total (Qt) or peak (Qp) reduces in all cases as a function of total rainfall. However, the reduction in Qt is only significant at the Aclands catchment.

- Results from pre-restoration monitoring suggest that the effect of drainage/restoration on the water table is spatially complex.

- Specifically, the water tables are lowest on the downslope side of any across slope drainage feature (Figure 9).
- The effect of this water table drawdown also appears to be limited to ca. 4 m from the drainage ditch.

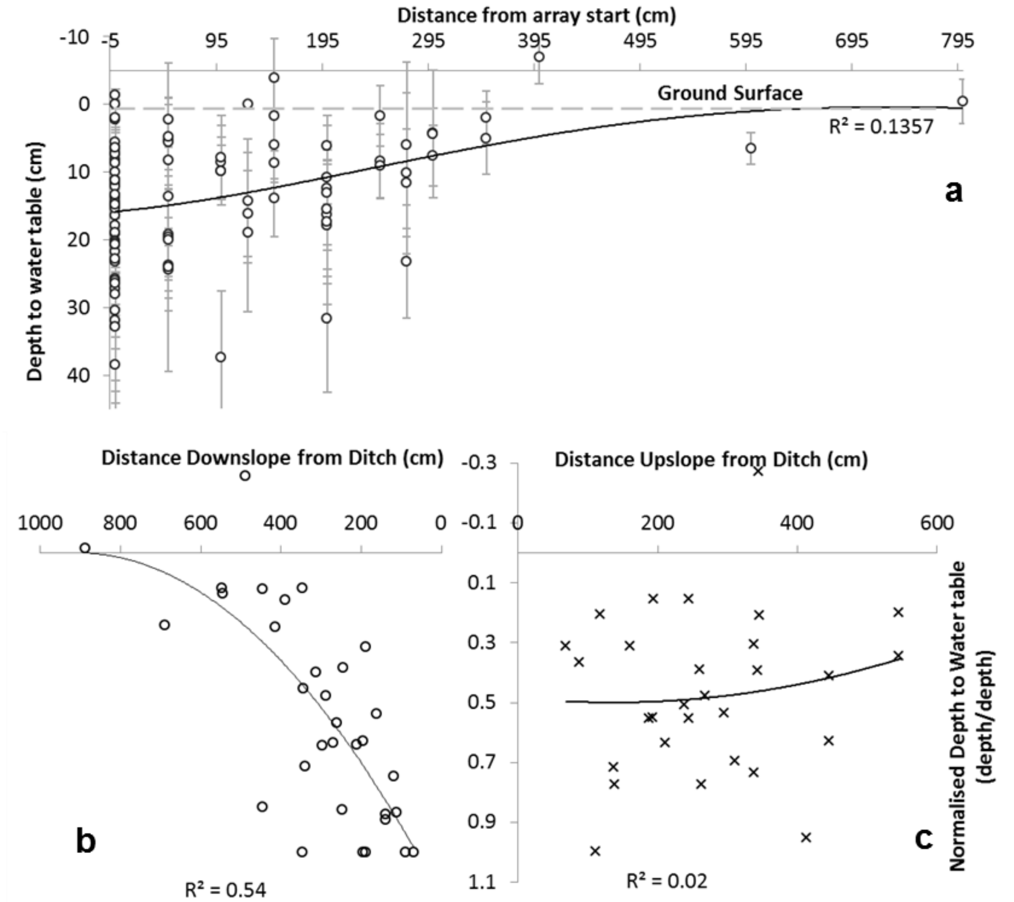

Figure 9 Mean (+/- standard deviation) depth to water table (DWT) (pre-restoration) for each of the 96 locations across all monitoring locations across both monitored catchments. a) Regression of mean (standard deviation error bars) DWT for all 96 monitored locations. b) Regression of mean DWT for all locations downslope of drainage features, depth is normalised by maximum recorded DWT at that experimental pool. c) Regression of mean DWT for all locations upslope of drainage features, depth is normalised by maximum recorded DWT at that experimental pool. From Luscombe (2016) in prep.

- Following restoration, water tables downslope of the drain are often closer to the surface.
- However, the change in water stored within the peat is spatially complex, with a maximum detected rise in water table of 21 cm and a maximum detected fall in water table of 11 cm.

3.4.2 Dartmoor

- Pre-restoration, this peatland loses water (runoff) in similarly flashy manor to Exmoor.
- Water table depths across the area of dendritic channels are spatially variable (Figure 10), with those areas further from bare peat having higher water tables, i.e. nearer the surface.

- In areas adjacent to bare peat, the water table is permanently below the surface and the upper peat soil is always dry.
- In the areas of bare peat the water table is normally just below the surface.

Figure 10 Spatially averaged Minimum, Mean and maximum depth to water table relative to the vertical position of the distance class in space, and for each of the distance classes measured. DW refers to the bare peat areas, 0-1 refers to those areas 0-1 meters from bare peat areas, and so on. The black line illustrates the spatially averaged surface height for each of the measured distance classes. Water tables are seen to be drawn up into the vegetated peat areas, with areas further away from the bare peat pans demonstrating the highest water table levels.

- To examine how these data change post-restoration, rainfall data and water level data from a subset of monitoring locations for the summers of 2014 (pre-restoration) and 2015 (post-restoration) are compared (Figure 11).
- Following restoration, our data show a marked change in water storage, with higher water tables in vegetated areas. In areas of bare peat, standing water is maintained throughout the summer period. However, the speed of water loss remained the same post-restoration.
- The average year on year increase in standing water was found to be ca. 14cm in the data subset used.

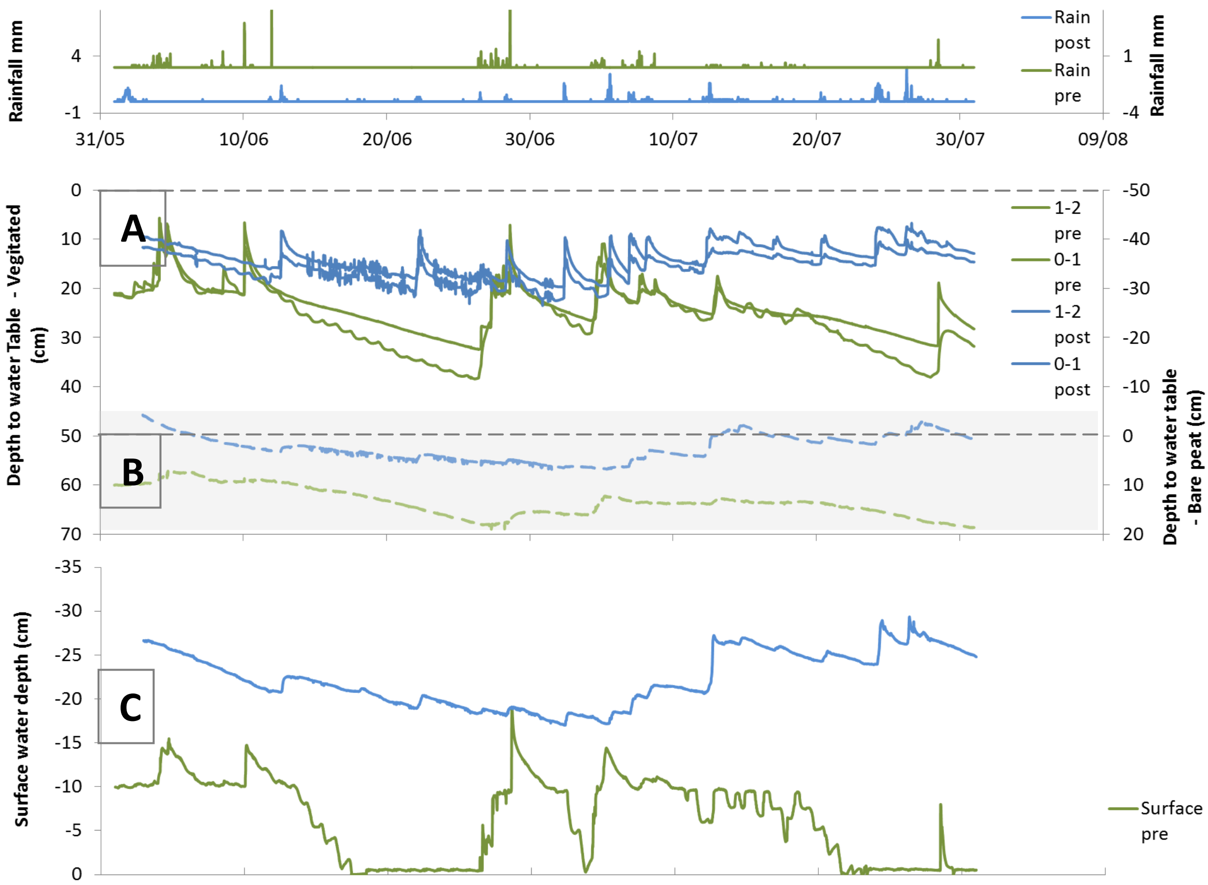

Figure 11 Data illustrating rainfall data and monitoring data from a subset of locations for the summers of 2014 (pre-restoration) and 2015 (post-restoration). Data illustrate (top) Rainfall, (A) Water table depth in vegetated areas, (B) Water table depth in the bare peat areas, (C) Standing water depth in the bare peat areas. In all-time series Green is pre-restoration and Blue post-restoration.

- Figure 12 shows post-restoration aerial photography captured in 2015, the pools of water following channel blocking are now clearly evident compared to unrestored areas.

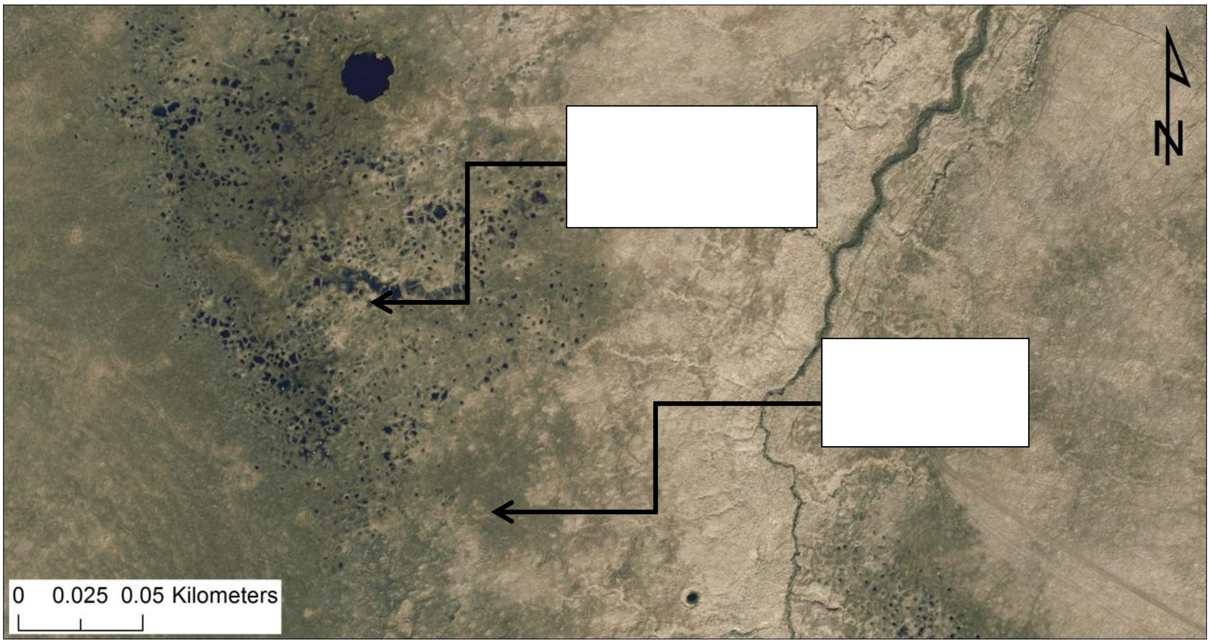

Figure 12 Post restoration aerial photography for Flat Tot Pan within Dartmoor National Park (from: Getmapping)

3.4.3 Future Research

Hydrological Monitoring will continue across all three catchments on Dartmoor and Exmoor. This will extend the post-restoration dataset and ensure that long term pre- and post-restoration datasets are comparable. Further work using remote sensing techniques will allow a better understanding of the change occurring after restoration on our study sites, but across the wider moorland area.

4 UNDERSTANDING THE EFFECT OF PEATLAND RESTORATION ON WATER QUALITY

4.1 Water quality and peatlands

In Europe, peatlands are soils found in wet and cold climatic conditions, and result from the accumulation of more or less decomposed plant remains in a water-saturated environment, free of oxygen. This lack of oxygen in the peat prevents microbial activity and therefore plant decomposition. The carbon becomes locked in a long term sink.

Rivers draining peaty catchments tend to be enriched in carbon (referred to as Dissolved Organic Carbon – DOC), giving the water a dark, tea colour. Local land management practices can exacerbate this problem: drainage for agricultural reclamation and peat cutting for fuel (particularly since the 19th century) has lowered the water table. This has allowed the air to penetrate into the peat stimulating microbial activity and plant decomposition. This has detrimental consequences, such as the loss of carbon from a long term carbon pool, negative effects on the biology within the stream, and the transfer downstream of metals, such as lead or copper, binding with the organic matter.

4.2 Importance of dissolved organic carbon for water companies

For water companies like South West Water which provide drinking water from peaty catchments (such as Dartmoor, Exmoor and Bodmin moor), colour is a problem: it has to be removed because it gives the water a low aesthetic value; if treated improperly, organic compounds can also react with chlorine to form carcinogenic decomposition by-products. The removal of dissolved organic carbon and colour from water is however a complicated and costly process.

It is expected that the process of blocking drainage ditches will raise the water table and reinstate waterlogged conditions, in turn limiting soil decomposition and dissolved organic carbon losses.

4.3 Why is this research important?

In deep peatlands, ditch blocking has been shown to increase dissolved organic carbon losses in the short term, but reduce concentrations and improve water quality in the long term. However, little is known about the behaviour of shallow peatlands that are located at the southernmost limit of the area allowing peat growth in the UK, especially in the context of the expected effects of climate change, and their potential for recovery.

4.4 Research questions

This research aims to understand the effects of peatland restoration on water quality in the short and long term, through the monitoring of two small catchments on Exmoor (Aclands and Spooners), and one catchment on Dartmoor (Flat Tor Pan).

4.5 Results so far

4.5.1 Extent of the work on Exmoor

- A total number of 151 and 95 rainfall events were sampled across both sites pre- and post-restoration respectively (Table 2); this represents over 3,000 samples collected and analysed.

Table 2 Number of events and samples taken for Aclands and Spooners pre- and post-restoration over the course of the monitoring programme and up to December 2014.

		Aclands					Spooners					Overall total
		EP1	EP2	EP3	Flume	Total	EP1	EP2	EP3	Flume	Total	
Samples	**Pre-**	271	183	232	271	**957**	222	223	234	217	**896**	**1853**
	Post-	23	35	156	85	**299**	332	197	252	160	**941**	**1240**
Events	**Pre-**	20	17	20	20	**77**	19	19	19	17	**74**	**151**
	Post-	5	2	10	8	**25**	18	15	20	17	**70**	**95**

4.5.2 Pre-restoration on Exmoor

- Dissolved organic carbon concentrations measured on Exmoor ranged between 5 and 25 mg L^{-1}, which is lower than what is experienced in damaged peatlands in the North of the UK;
- Aclands experiences worse water quality than Spooners, with higher dissolved organic carbon and colour concentrations, due to the fact that the site is generally drier, and therefore has more potential for decomposition.

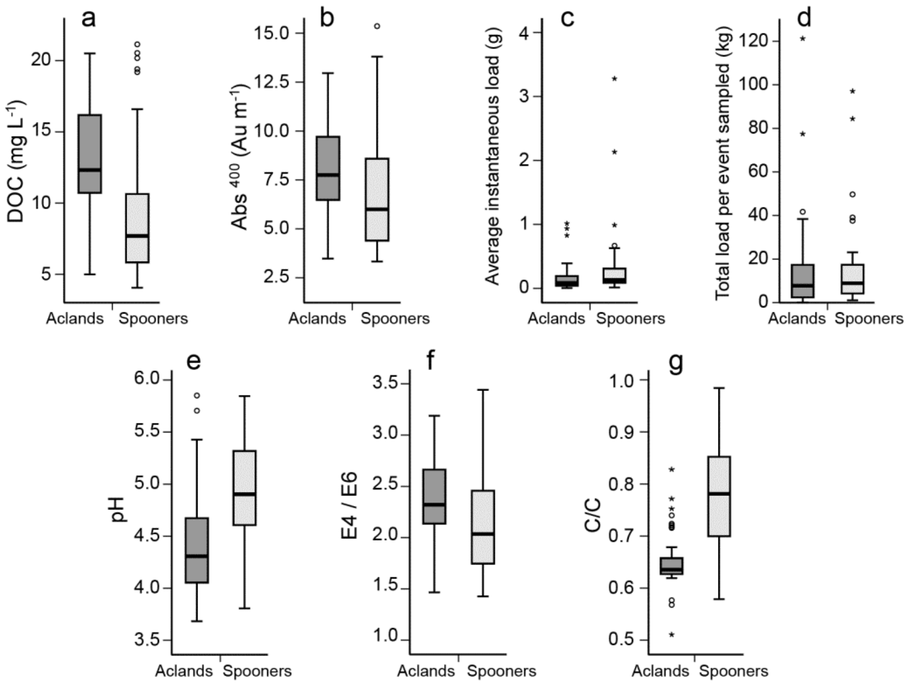

Figure 13 Boxplot diagrams of the DOC (a), colour (b), instantaneous loads per event (c) Total load per event samples (d), pH (e), E4/E6 ratios (f), and C/C (g) (from Grand-Clement et al., 2014).

- However, differences in river discharge between the two sites mean that they have similar carbon loadings, which are defined as the amount of carbon that is actually transported by the stream.
- Humification ratios (E4/E6) is an indication of the characteristics of the dissolved organic carbon. Values consistently below 5 for both sites indicate that the dissolved organic carbon is mostly composed of humic acids, which represent the more complex compounds of dissolved organic carbon.
- There is a strong seasonal trend, with higher dissolved organic carbon concentrations measured at warmer, drier times of year (

- Figure 14);

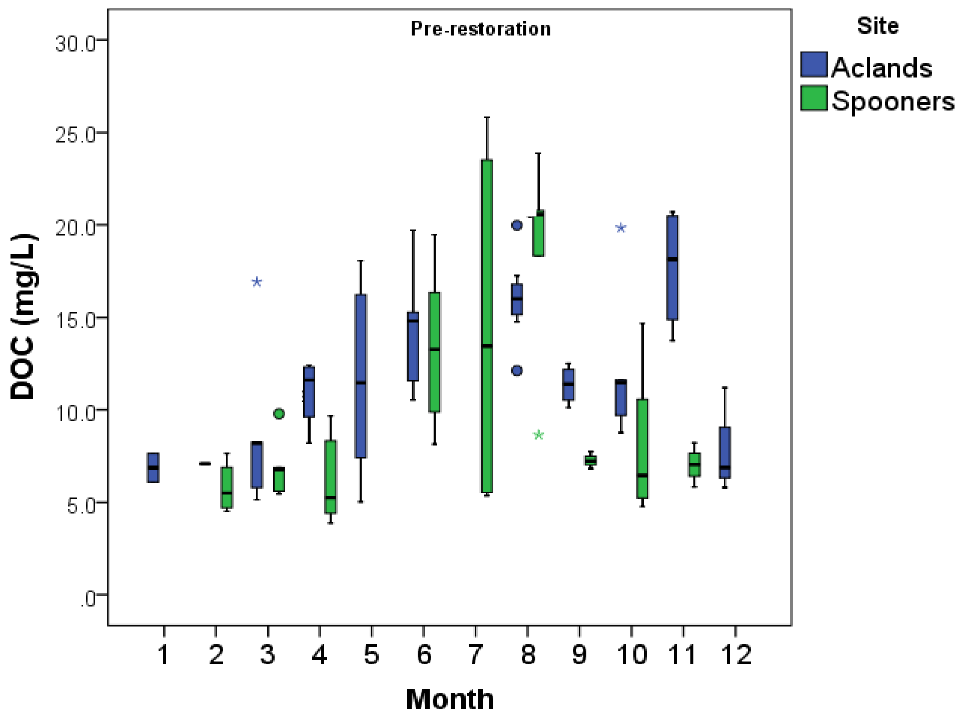

Figure 14 Annual variations of DOC concentration throughout the year for Aclands and Spooners; * relates to outliers in the dataset

- On Exmoor, dissolved organic carbon losses result from the balance between what is produced, and how much is transported and exported during rainfall/runoff events. Our pre-restoration work (i.e. Grand-Clement et al., 2014) has shown that dissolved organic carbon losses are influenced by the following drivers:
    - long-term depth to water table (i.e. 30 days before the rainfall events), (*production*);
    - total discharge during storm events (*transport*)
    - temperature at the start (*transport through the physical process of diffusion*)

4.5.3 Effect of restoration on Exmoor

- The effects of restoration on dissolved organic carbon concentrations varies between Aclands and Spooners: dissolved organic carbon concentrations were observed to rise after restoration at Spooners, which is similar to the short-term change in dissolved organic carbon generally observed elsewhere; however no significant change was observed on Aclands. This may partly be due to the differences in duration since restoration between datasets.
- Dissolved organic carbon concentrations and loadings are largely driven by hydrological parameters (i.e. how much water is leaving the catchment) and the restoration, but inter-annual climatic variability (i.e. temperature and total rainfall) also have a strong influence. Annual dissolved organic carbon loadings and changes post-restoration are currently being estimated.

4.5.4 Dartmoor pre-restoration

Table 3 Number of rainfall events and samples collected, and selected after event separation analysis, pre-restoration for both Dartmoor sites, namely Dartmoor Upper EP (DU) and Dartmoor Flume (DF).

Restoration	EP	High flow events			High flow samples		
		Sampled	Selected	%	Sampled	Selected	%
Pre-	DF	12	10	83	182	167	92
	DU	27	14	52	331	231	70
	Total	39	24	62	513	398	78

- Over the sampling period (until December 2014) 24 rainfall/runoff events were sampled, representing a total number of samples used of 398 (Table 3).

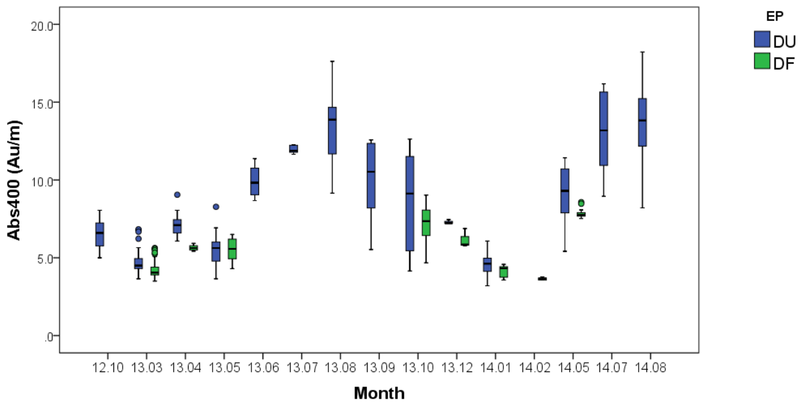

Figure 15 DOC (top) and colour (bottom) variations throughout the year on Flat Tor Pan.

- Both dissolved organic carbon concentrations and colour (Abs400) measured on Dartmoor show a clear seasonal effect, with concentrations rising during the drier, warmer summer months (June to September) (Figure 15), similar to Exmoor.
- Overall, dissolved organic carbon concentrations ranged between 7 mg L^{-1} in March 2013, to 28 mg L^{-1} in August 2013.

4.5.5 Dartmoor post-restoration

Post-restoration data at Dartmoor is currently being collected with a total of six events (144 samples) monitored so far.

4.6 Future research

Monitoring is being continued on all sites, which will allow the effects of restoration in the long-term to be quantified. On Dartmoor, we aim to quantify the initial change occurring after restoration. Work is also currently being undertaken to estimate annual dissolved organic carbon loadings preand post-restoration, as well as analysing the dissolved organic carbon behaviour during rainfall/runoff events.

5 THE EFFECT OF PEATLAND RESTORATION ON GREENHOUSE GAS EMISSIONS

5.1 Background

In a functioning peatland the amount of vegetation growth is ever so slightly greater than the amount of vegetation decay leading to a gradual accumulation of carbon-containing organic matter. Drainage ditches (Exmoor) and erosional channels (Dartmoor) lower the water table which increases the depth to which oxygen can diffuse, promoting decay leading to carbon loss. Over time the vegetation present will change to suit the new drier conditions leading to a decrease in *Sphagnum* moss and an increase in grasses such as Purple Moor grass (*Molinia caerulea*) further promoting decay.

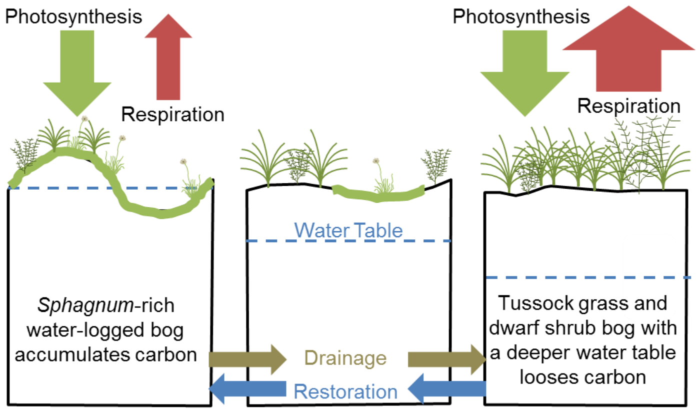

Figure 16 Effect of drainage and possible effect of restoration on water tables, vegetation and carbon dioxide fluxes. Based on Lindsay (2010).

It has been proposed that restoration (ditch/channel blocking) can reverse these processes. In the short-term restoration aims to raise the water table causing the peat to become water-logged, preventing oxygen diffusion and therefore reducing decay. This should prevent further losses from the existing peat store built up over the last millennium. Over the longer-term wetter conditions should promote *Sphagnum* growth and suppress Purple Moor grass growth shifting the balance between growth and decay resulting in carbon accumulation.

Another greenhouse gas exchanged between a peatland and the atmosphere and therefore affected by restoration is methane. Methane is produced by bacteria in anoxic conditions (oxygen free), usually deeper in the peat. There are three routes by which methane can reach the atmosphere; 1 – as bubbles (ebulltition), 2 – diffusion through the peat and 3 – diffusion through some vegetation e.g. Bog Cotton grass (*Eriophorum angustifolium*). Where the water table is low, routes 1 and 2 are restricted as methane is oxidised to carbon dioxide before reaching the surface. Raising water tables by restoration enlarges the zone where methane can be produced, enables all three transport routes and promotes the growth of water loving species including Bog Cotton grass (*Eriophorum angustifolium*). In the short-term restoration would be expected to increase methane emissions to become more similar to an intact bog.

As methane has a shorter lifetime in the atmosphere than carbon dioxide over time the additional carbon dioxide drawn-down into a restored bog should more than compensate for the additional methane released.

5.2 Why is this research important?

Carbon trading markets, supported by initiatives such as The Peatland Code, may provide funds to restore degraded peatlands. These schemes require appropriate, evidence-based emissions saving in order to quantify the carbon saved by restoration and therefore the economic value of this activity. Prior to the start of this study there was no data on carbon dioxide or methane fluxes from Purple Moor grass dominated peatlands as found on Exmoor and Dartmoor, a need to quantify greenhouse gas emissions was identified in order to support such schemes.

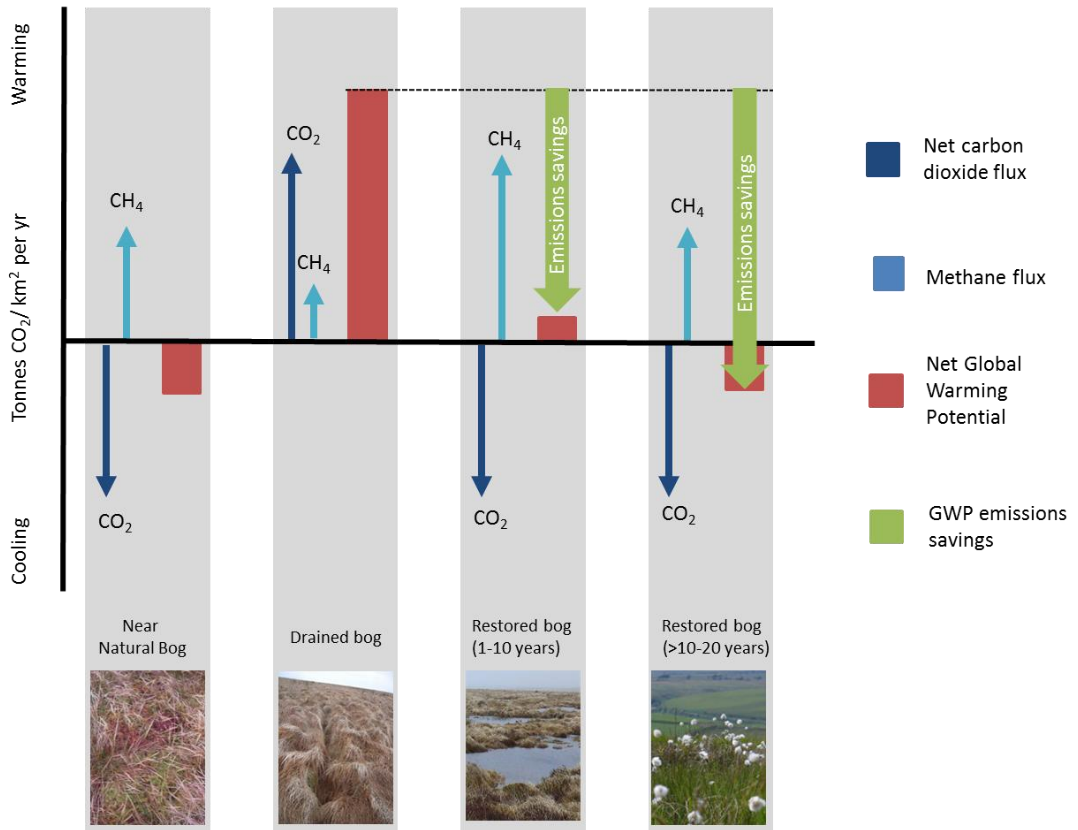

Figure 17 The Global Warming Potential of carbon (carbon dioxide and methane) emissions from a near natural, drained and restored bog and emissions savings due to restoration. Based on Bain et al. (2011).

5.3 Research Questions

Initially research tried to understand the relationships between water table depth, vegetation composition and carbon dioxide fluxes (photosynthesis, ecosystem respiration, total below-ground respiration, root respiration (autotrophic) and soil respiration (heterotrophic)) in damaged peatlands. A companion study by Adam McAleer (University of Bristol) investigated methane. Following restoration (Spooners 2013 (Exmoor), Aclands 2014 (Exmoor) and Flat Tor Pan 2015 (Dartmoor) research has focused on quantifying and understanding the effect of restoration on carbon dioxide fluxes and the processes controlling them. Since April, research has also been trying to quantify and understand the effect of restoration on methane emissions.

5.4 Results so far…

5.4.1 Exmoor Prior to Restoration

- Water table depths were deepest closest to the ditch and shallower further away, however this relationship was not statistically significant.
- Carbon dioxide fluxes did not vary spatially with distance from the ditch probably due to the insignificant variation in water table depth and vegetation composition.
- Vegetation species diversity and the total coverage of non-Purple Moor grass species were greater in wetter locations.

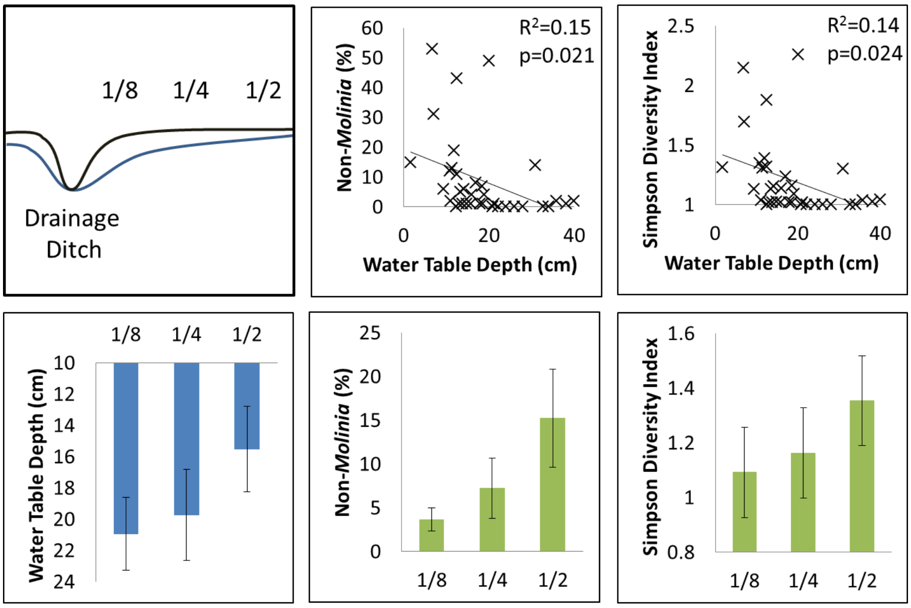

Figure 18 Pre-restoration variation in water table depth (bottom left), non-Molinia coverage (Purple Moor grass) (bottom middle) and species diversity (Simpson diversity index) (bottom right) with proportional distance (⅛, ¼, ½) distances between adjacent ditches. Variation in non-*Molinia* coverage (Purple Moor grass) (top middle) and species diversity (Simpson diversity index) (top right) with water table depth.

- Photosynthesis was greater where water tables were deeper and during drier periods.
- Contrary to expectation, soil respiration did not decrease during wetter conditions possibly as most of the respiration occurred in the top few cm of the peat/leaf litter layer located above the water table.
- Over the year there is considerable variation in photosynthesis and ecosystem respiration associated with the growth and decay of the vegetation.

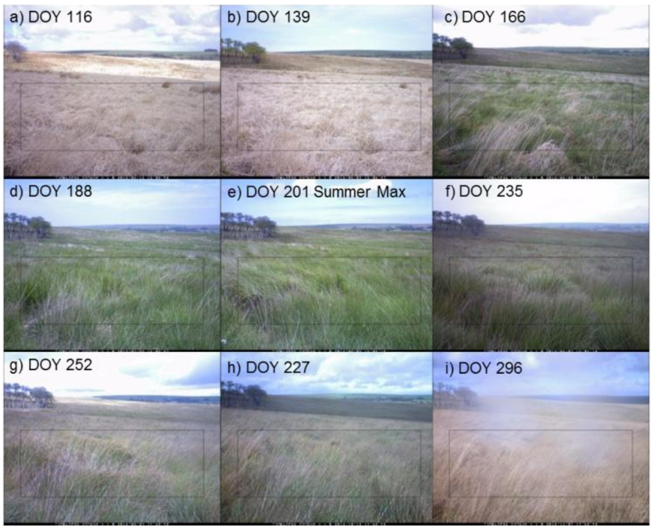

Figure 19 Seasonal growth and decay of the vegetation as captured by a time-lapse camera drives variation in photosynthesis and ecosystem respiration.

- An empirically derived net ecosystem exchange model estimated that in a degraded state the Purple Moor Grass dominated peatlands of Exmoor are losing carbon dioxide to the atmosphere demonstrating the need to restore these peatlands in order to protect carbon stored.

5.4.2 Exmoor Post-Restoration

- Due to a wet pre-restoration year (2012) followed by dry post-restoration years (2013, 2014) measured water tables fell following restoration. Allowing for climatic variability restoration had no impact on summer water tables.
- There was also no significant change in vegetation observed following restoration.
- Consequently there was no significant change in carbon dioxide fluxes.
- This suggests in the short-term that ditch blocking may not raise water tables sufficiently to affect carbon dioxide fluxes and promote the vegetation change (to *Sphagnum*) required to return these peatlands to carbon accumulation.

5.4.3 Dartmoor Prior to Restoration

- Greater vegetation coverage and diversity on the vegetated haggs resulted in an order of magnitude difference in measured carbon dioxide fluxes between the vegetated haggs and peat pans.

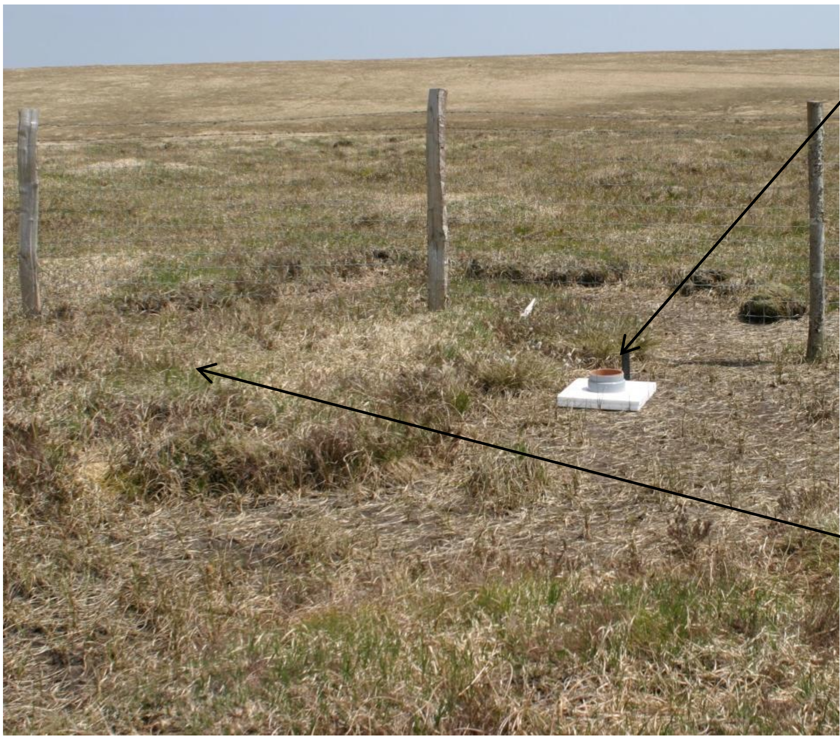

Figure 20 Typical vegetated hagg – peat pan monitoring pair on Flat Tor Pan prior to restoration.

- An empirically derived net ecosystem exchange model estimated that over the summer (May to September) the vegetated haggs were carbon dioxide sinks but the peat pans were a source of carbon dioxide. Limiting expansion of these bare peat pans is critical if further biodiversity and carbon are not to be lost.

5.4.4 Dartmoor Post-Restoration

- Flooding of the control sites has made separating the effects of restoration from the effects of climate difficult.
- Water levels rose following restoration.
- In the summer following restoration there was no change in vegetation composition however, this is a short period of time to expect a change in vegetation.
- Photosynthesis increased following restoration due to better growing conditions, this could be due to climate or restoration (e.g. alleviating moisture stress).
- The high rates of below-ground respiration (from roots and stored carbon) associated with dry periods observed prior to restoration were not observed post-restoration, possibly due to higher water tables. This suggests that restoration has reduced losses of CO_2 from below-ground sources. However, without a control-restored paired design it is not possible to quantify this reduction. New control sites are planned for the 2016 growing season to try to separate the effects of climate from restoration.

5.5 Future Research

Monitoring will continue at Aclands, Spooners and Flat Tor Pan to understand and quantify the short to medium-term effects of restoration on greenhouse gas emissions (now including methane), vegetation and water table depths. This summer it is planned to run an experiment across a gradient of wetness from a Bog Cotton Grass and *Sphagnum* community through to dry Purple Moor Grass community to understand and quantify greenhouse gas fluxes from the range of vegetation communities found on Exmoor.

6 GLOSSARY

C/C- Colour per carbon unit, calculated by dividing absorbance values via which colour was determined via the corresponding sample DOC concentration.

DWT – Depth to Water Table – this describes the depth below the surface that the water table is detected.

Instantaneous Load – amount of water quality determinant at sampling point for a given moment in time. Calculated by multiplying discharge by concentration.

Net Ecosystem Exchange – NEE – the net balance of photosynthesis and ecosystem respiration

Normalized Difference Vegetation Index - NDVI – Active, healthy vegetation reflects potentially damaging near infra-red light but absorbs red light in order to photosynthesis. NDVI is a ratio of infra-red to red light, normalised by total near infra-red and red light to account for variation in brightness (NDVI = (NIR-Red)/(NIR+Red) It ranges from -1 to 1 with higher values associated with greener vegetation.

Rain fall runoff event classes – These classes are used to describe the type of hydrograph associated with an individual event. The table below details the classifications. Importantly, class 1 and 2 events are the most easy to understand and extrapolate, and are therefore used in preference for some of the analysis.

Total Load – total amount of water quality determinant lost/transported over the event time sampled.

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