# Restoration of Blanket bogs; flood risk reduction and other ecosystem benefits

## Annex 3. Particulate Organic Carbon

Mike Pilkington, Tia Crouch

*Moors for the Future Partnership, Edale, S33 7ZA, UK*

## Final report of the Making Space for Water project

## Prepared for

## By

## Moors for the Future Partnership, 2015

Moors for the Future Partnership
The Moorland Centre,
Edale,
Hope Valley,
Derbyshire,
S33 7ZA, UK

T: 01629 816 579
E: research@peakdistrict.gov.uk
W: www.moorsforthefuture.org.uk

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Suggested citation:
Pilkington, M & Crouch, T. (2015). *Annex 3: Particulate organic carbon.* In Pilkington M.G. et al. (2015) *Restoration of Blanket bogs; flood risk reduction and other ecosystem benefits.* Final report of the Making Space for Water project: Moors for the Future Partnership, Edale.

## CONTENTS



**FIGURES**

## SUMMARY

The transport of eroding peat particles (POC) in erosion gullies during storms is a major source of fluvial carbon loss from damaged blanket peats such as those found in the Dark Peak and South Pennines. Climate change predictions suggest that these losses may be exacerbated in the future leading to an increase in the rate of silting of reservoirs and increased problems with drinking water supplies. Recent restoration activities, including re-vegetation, are likely to reduce the rate of erosion of peat but there is insufficient evidence to quantify this effect. POC was measured in gully flow using simple, easy to fabricate passive samplers in both severely eroding and recently restored micro catchments on Kinder Scout. Re-vegetation of eroded micro catchments caused a 90% reduction of POC transport in gully flow.

## 1. INTRODUCTION

Globally, blanket peats contain a major store of particulate organic carbon (POC). During storms, POC eroding from the surface of bare peat patches on damaged peatlands is transported in suspension in rain water flowing down erosion gullies where it can contribute to the sedimentation of reservoirs and the release of atmospherically deposited pollutants (especially toxic heavy metals) thus compromising both ecosystem sustainability and the quality of drinking water.

Climate change predictions of hotter, drier summers would promote a greater risk of severe accidental fires, desiccation and subsequent greater exposure of bare peat, while predictions of stormier winters would promote increased rates of erosion of POC from the exposed peat and greatly exacerbated losses of POC from blanket peats.

This episodic nature of POC loss has in the past led to underestimations of its importance relative to that of dissolved organic carbon (DOC) losses; however, recent studies have shown that losses of POC may account for approximately 70% of the fluvial carbon budget (see Shuttleworth et al, 2014).

Re-vegetation of eroding peatlands has been a major part of recent intensive restoration activities carried out by Moors for the Future in the uplands of the Peak District and South Pennines. Re-vegetation of the gully floor has been shown to be a major factor controlling the loss of POC from damaged peatlands (Evans et al., 2006). The aim of this study is to provide evidence of a reduction in loss of POC due to re-vegetation of the Making Space for Water project area. The specific objective is to compare the amounts of trapped particles sampled from head water gullies of the untreated control catchment of the Making Space for Water hydrological experiment with those of the (a) re-vegetated and (b) re-vegetated and gully blocked catchments in a snapshot time period.

## 2. METHODOLOGY

A simple passive sampling device, the “TIMS” unit (Time-Integrated Mass Flux Sampler), as used by the University of Manchester (Shuttleworth et al, 2014), was considered ideal for use in these systems which exhibit highly variable flow patterns, as these devices lie flat along bottom of gullies, and continue to passively capture POC over sequential storm events and even during low flow periods. The original TIMS unit was equipped with a water-sensitive logging device which provided information on the amount of time the unit was exposed to water: hence the term “Time-Integrated”; and also the area of the catchment being sampled was measured: hence the term “Flux”. For the purpose of this study, no water sensitive logging device was used and no measurement of catchment area was made - a simple “snapshot” approach was considered sufficient. This involved placing a replicated set of 10 units in similar sized and shaped headwater gullies and at similar locations relative to the origin of the gully, in both restored and unrestored areas, and for similar periods of time.

A pilot study was first designed to test the structure and robustness of the newly-constructed TIMS units and the suitability of the proposed methodology. Five TIMS units were staked to the bottom of headwater gullies in each of an eroded micro catchment and five TIMS units were staked to the bottom of similar headwater gullies in a re-vegetated micro catchment on 19th August 2013. The units were collected in again on 19th September 2013, after an exposure of 32 days.

In the second, main study, ten TIMS units were staked to the bottom of gullies in the three “Making Space for Water “Edge” area micro-catchments, the eroded control, a re-vegetated and a re-vegetated plus gully blocked micro catchment. The exposure time was from the 10th October to the 7th November 2013, a total of 28 days.

## 2.1 Construction of TIMS

Standard white PVC plumbing pipe with internal diameter 50 mm was cut into 50 cm lengths; rough edges were smoothed and all crud rinsed from the inside. Araldite glue was used to fasten a stiff plastic mesh (minimum 8 mm aperture) disk to one end of the pipe. When dry, the tube was filled with polystyrene packing chips and the second disk glued on to the other end of the pipe to enclose the chips. Duct tape was applied around the pipe at two locations, 10 cm from both of the ends and then two heavy-duty zip cables were fastened tightly around the pipes over the tape with smaller sized zip cables, one in each location, trapped beneath (these are used to fasten the TIMS to the wooden stakes). Wooden stakes were pre-drilled in preparation for screwing in steel eyes and fastening to the TIMS units.

## 2.2 Equipment required for construction of TIMS units

| | |
|---|---|
| PVC pipe (50 mm (ID) X 500 mm) | (http://www.screwfix.com/jsp/container.jsp) |
| Polystyrene chips | ukpackaging.com |
| Plastic 8 mm mesh | Plastok Associates |
| Araldite glue | intertronics.co.uk |
| Large Polythene Sample bags | ukpackaging.com |
| Metal eyelets | http://www.screwfix.com/jsp/container.jsp |
| 2 X large cable ties per TIMS | http://www.screwfix.com/jsp/container.jsp |
| 2 X small cable ties per TIMS | http://www.screwfix.com/jsp/container.jsp |

## 2.3 Field placement of TIMS

The boundary polygons of three of the Making space for Water project micro catchments were superimposed on aerial photographs to locate potentially suitable headwater gullies within each of the different treatment micro catchments. The coordinates of these gullies were noted and then surveyed in the field. Gullies from all micro catchments were chosen to be of similar size (depth, width (at a height of 1 m) and angle of sides) and slope (gentle; between approx. 0 – 5°). The location of the TIMS units within the gully was generally between 25 m and 50 m of the gully origin – GPS coordinates were noted. The TIMS units were fastened (with zip cables) to metal eyes screwed into wooden stakes that had been driven into the soft peat (Fig. 1). All the TIMS units were placed on the same day.

**Fig. 1. TIMS units staked to the bottom of a re-vegetated (left) and an eroded gully (right).**

## 2.4 Field collection of TIMS

After approximately 30 days of exposure, a GPS device was used to relocate the TIMS units. The units were photographed and a visual assessment was made to characterise the gully bottom and sides extending 5 m upstream of the location. This assessment included channel width on the gully bottom, gully width at 1 m height, gully depth and approximate percentage of bare peat on the sides. All units were collected on the same day and in the same order of placement. The cable ties were cut and the unit gently raised and angled so that any residual water slowly drained out in the direction of flow down the gully. The units were dried and clearly labelled and then smaller plastic bags were used to block both ends of the units with duct tape. Five of the units (from the same micro catchment) were then sealed into heavy duty plastic bag with duct tape. On return from the field, the units were kept in a cool place and packaged ready for transport by courier to Ryal Soil and Ecology (East Farm Cottage, Ryal, Northumberland, NE20 0SA (Tel; 01661 886918, soils@ryal.freeserve.co.uk).

## 2.5 Laboratory analysis of TIMS

The contents of the tube were emptied by stages through an 8 mm sieve into a large bucket or basin. Particles of peat were usually stuck to the polystyrene chips and needed to be separated by swirling with deionised water before passing again through a sieve and squirted with more deionised water or brushed to get the smaller particles off (Fig. 2). Where a significant amount of sample had been collected, the samples were left to settle in pre-weighed 2l beakers for 7 days before decanting off the water. The water was filtered through a pre-weighed filter paper using a Buchner Funnel filter system. The remaining sediment sludge and the filter paper were dried in an oven for approximately 12 hours, (until 2 successive weight readings gave no change), and then weighed to an accuracy of 0.01 g. On samples where filter water was not clear, a 500 ml sample taken (after vigorous agitation) and oven dried.  Sediment loading of the filtrate calculated on the total volume and added to the net weight of sediment caught on the filter.

Where a small amount of sample has been collected, the samples were vacuumed-filtered through pre-weighed 1.2µm filter papers. These were dried and weighed as above.

**Fig. 2. Emptying the TIMS units in the laboratory (left) and the contents (right).**

## 3. RESULTS OF PILOT STUDY (AUGUST/SEPTEMBER 2013)

This pilot study revealed two key findings: (i) High variability between replicates (Fig. 3); one unit from each of the 5 replicates had more than three times the amounts of POC than that found in others of their set and this was probably the result of chance events such as gully wall collapse immediately upstream of the unit causing disturbance of sediment; (ii) the amount of POC trapped in the TIMS units that had been placed in re-vegetated gullies was at least 90% lower than the amount trapped in equivalent units placed in eroded gullies (Fig. 4).

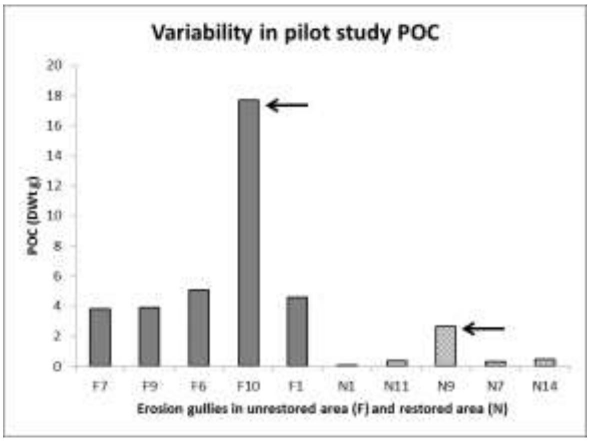


**Fig. 3. Variability in weight of POC (g Dry Wt) trapped in TIMS units.**
*The bars show data from individual replicates (n = 5) and outliers are marked by arrows. Length of exposure was from 19th August 2013 – 19th September 2013 (32 days).*

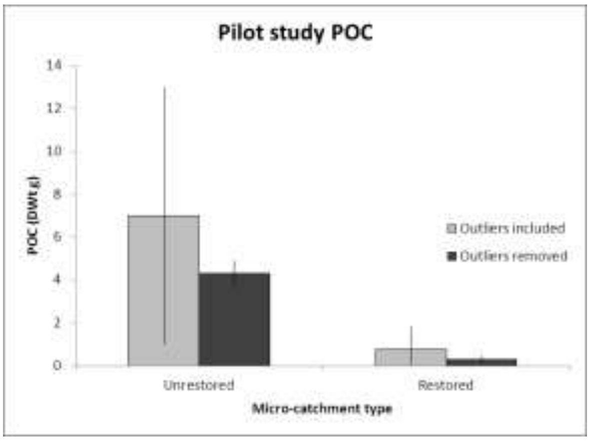


**Fig. 4. Mean weight of POC (g Dry Wt) trapped in TIMS units of the Pilot study.**
*The lighter shaded bars show the mean weight of POC with the outliers included; the darker shaded bars show the mean weight of POC with the outliers removed. Length of exposure was from 19th August 2013 – 19th September 2013 (32 days) (n = 5, error bars indicate ± 1 standard deviation)*

## 4. Results of Main Study (October – November 2013)

These results were similar to those of the pilot study and confirmed that (a) there is high variability between samples and (b) restoration of headwater catchments is associated with a mean reduction of POC suspended in gully flow of more than 90%.

However, these results specifically showed that re-vegetation was the main cause of the decrease, reducing the amount by 97%, while the reduction in micro catchments which were re-vegetated and gully-blocked was only slightly greater (99%) (Fig. 5).

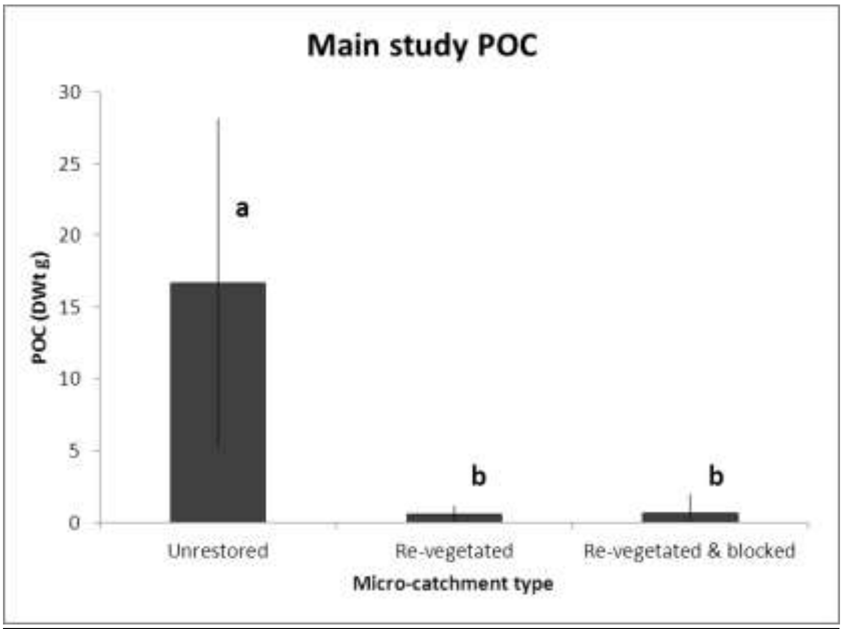


**Fig. 5. Mean weight of POC (g DWt) trapped in TIMS units of the main study.**
*Length of exposure was from 10th October 2013 – 7th Nov 2013 (28 days). Error bars indicate ± 1 standard deviation, bars labelled with different letters are significantly different, Mann Whitney U test, n = 10, p < 0.001).*

## 5. CONCLUSIONS

Re-vegetation of previously eroded blanket peat is highly successful in reducing the amount of POC in fluvial suspension in gully flow on eroded headwater catchments. The effect is found relatively quickly; the re-vegetated micro catchment had been treated with seeds only 2 years previously. Shuttleworth et al (*2014*) also found similar reductions in head water catchments that had been re-vegetated several years previously and other research by Evans and Warburton (2005) has shown that vegetation filters particles from overland flow thus contributing to the redeposition of peat and a dramatic decline in erosion rates.

## 6. REFERENCES

Evans, D.J., Gibson, C.E. and Rossell, R.S., 2006. Sediment loads and sources in heavily modified Irish catchments: A move towards informed management strategies. Geomorphology, 79(1-2): 93-113.

Evans, M. and Warburton, J., 2005. Sediment budget for an eroding peat-moorland catchment in northern England. Earth Surface Processes and Landforms, 30(5): 557-577.

Evans, M., and Warburton, J., 2010.Peatland geomorphology and carbon cycling. Geography Compass 4/10: 1513–1531

Shuttleworth, E. L., Evans, M. G., Hutchinson, S. M. and Rothwell, J. J., 2015. Peatland restoration: controls on sediment production and reductions in carbon and pollutant export. Earth Surface Processes and Landforms, 40(4): 459–472.

## 7. ACKNOWLEDGEMENTS

Tim Allott, Martin Evans and James Rothwell provided general advice on the scale and design of the experiment. Emma Shuttleworth provided detailed guidance on the design of the TIMS units. James Cooper (Conservation Works Officer) assisted with construction of the TIMS units.