Interreg
North-West Europe
Care-Peat
European Regional Development Fund

Deliverable WPI3 1.1
Restoration plan of the UK pilot:
Companion planting, Little Woolden Moss

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Version History

Date	Author	Version
12/01/2020	ML	Version 1
28/2/2020	ML, SJ, JK, AK	Version 2
29/7/2020	ML, SJ, JK, AK	Version 3

Table of Contents

1.0 Introduction

Deliverable	I3 1.1
Deliverable name	Jointly refined restoration plan
Deliverable deadline	September 2019
Status	Completed
Remarks	The plan is under constant review in order to capture necessary changes as progress proceeds.

This report provides an overview of the approach taken to pilot a companion planting method for the restoration of a former lowland raised bog that was commercially mechanically extracted for peat.

Further details will be provided in the subsequent report detailing the progress, accomplishments and outcomes under other Care-Peat deliverables.

2.0 Background

Peatlands are not only habitats with a highly specialised flora and fauna, they also play an important role in global climate regulation. Peatlands are the most efficient carbon sink on the planet - northern hemisphere peatlands account for three to five per cent of total land area but contain approximately 33 per cent of global soil carbon. Therefore, peatlands have a strong natural potential to save carbon and play an important role in nature-based solutions for climate change.

Yet many peatlands are in poor condition through drainage, conversion to agriculture, peat extraction and also historic pollution. Drainage causes carbon that has been stored over thousands of years to oxidise and return to the atmosphere as carbon dioxide, contributing to large-scale greenhouse gas (GHG) emissions. These carbon stores are further threatened by climate change which is likely to increase the rate of decomposition. The global annual GHG emissions from drained organic soils are currently twice that from aviation.

The restoration, rewetting and sustainable use of peatlands are therefore seen as vital in climate change mitigation measures and key to achieving the EU aim to be carbon neutral by 2050. This pilot is part of the EU-funded Interreg Care-Peat project which is investigating new methods to reduce carbon GHG emissions and restore the carbon storage capacity in European peatlands.

3.0 Aims and Objectives

The aim of the companion planting pilot is to build on earlier research carried out between 2016 and 2018 at the neighbouring site of Cadishead Moss by Manchester Metropolitan University (MMU), which looked at the relationship between types of vegetation cover and GHG fluxes. The aim of this Care-Peat pilot is to test:

1. The establishment rate of desired ground coverage of vascular plant communities found in lowland raised bog habitat.
2. Whether the chosen plant assemblage provides a supportive environment for reintroduction and establishment of hummock-forming *Sphagnum* species.

3. Whether the chosen vascular and *Sphagnum* plant assemblage is successful in converting an area of bare peat from a state of emitting gaseous carbon to sequestration.

4.0 Location and Site Description

The companion planting pilot area is located on Little Woolden Moss (LWM), 107 ha of lowland raised bog degraded through commercial peat extraction, which has been owned since 2012 by the Lancashire Wildlife Trust and is located in the Metropolitan District of Salford in Greater Manchester (see Appendix 7.1). There are over 6000 ha of lowland peatland across Greater Manchester, which varies from recently extracted peatland, such as LWM, to various forms of agriculture on peat.

The area chosen for the pilot is 2 ha of a recently re-wetted area of bare peat. Until end-of-tenure on 31 December 2017, this area was commercially extracted for peat. In spring 2018 work began to re-wet the area through filling in the internal drainage ditches spaced approximately 16 m apart, leaving a landscape of hummocks and hollows, and later by bunding work. The peat quality is poor, highly degraded, and the most obvious plant remains within it are grass, heather and wood (peat constituents not yet fully assessed). The depth varies between 0.8 and just under 2 m (measured with threaded rods only). Underneath this peat is a thin layer of glacier-deposited sand overlaying clay, with wood underlaying the peat in places. The northern end of the pilot site (with the shallowest peat layer) tends to retain surface water after heavy rain. The GHG monitoring collars and dipwells are located at the southern end of the site.

5.0 Site Summary and Current Status

GPS of the site centre	SJ 692 949
Size of the site - as a whole and area of the pilot (Ha)	Whole site is 107 ha, 2ha of which is being used for the companion planting pilot
Type of peatland	Lowland raised bog. Commercially extracted until Jan 2018
Landowner	Lancashire Wildlife Trust (LWT)
Ownership of surrounding land	LWT and private landowners: The pilot site lies within the boundary of Little Woolden Moss, fully owned by LWT. Surrounding Little Woolden Moss is agricultural land, separated by a large drainage ditch.
Local stakeholders	Stakeholders include LWT and the adjacent landowners, as well as Natural England due to the position of the site near to the Manchester Mosses SAC. Other stakeholders could include local residents and other local businesses/landowners who may be interested.
What is the position in the landscape?	The area designated for the pilot site is immediately bordered on all sides by areas of bare peat, on a corner of Little Woolden Moss. The rest of LWM is in various stages of restoration. The habitat surrounding LWM is farmland used for livestock and winter feed crops and patchy areas of woodland.
Current site management	The wider site is currently in the process of being restored through rewetting by bunding and ditch-blocking and revegetated with a mixture of bog characteristic plants including *Eriophorum* spp. and *Sphagnum*.
Is the site currently degraded? If so, what activities have caused the degradation?	Yes. Bare peat on pilot site due to previous commercial extraction.

Is the site impacted by pollution, historic or current?	Yes, it is likely to be affected by air-borne N pollution from the nearby M62 motorway and nearby major cities and industrial areas. The site is approx. 8 miles from Manchester. The surrounding area is agricultural so it's possible there may be impacts from fertilizer/nutrient application or run-off.
Avg. meteorological conditions at the site	Average July temp: 19 degrees C Average January Temp: 5 degrees C *Average rainfall: 4.99 cm* *(data source: BBC weather) TO BE CONFIRMED with site data logger information*
Site hydrology / topography	
How wet is the site on a scale of 1-5? 1 representing a firm heathland, 5 representing a Swingmoor floating bog?	Currently 2-3 due to drainage
Is the site currently losing water? Are there any local sources of water that could be used to aid rewetting?	Site is currently undergoing rewetting and measures to improve hydrological stability. No sources of suitable water nearby.
What is the overall site topography?	Area has been mostly levelled due to peat-milling and subsequent filling of drainage ditches. Firm ex-peat extraction beds and softer ditch infill had left a network of humps and hollows.
Does the site have potential for rewetting?	Large areas have the potential to be rewetted and restored.
Current surveys of topography / hydrology?	Lidar data available. Dipwells installed in 2014/15.
Site vegetation and wildlife	
Current vegetation on the site?	Bare peat in the pilot area. Mix of fen and bog vegetation in previously restored areas of LWM.
Are there any peat forming species present?	No, not in the pilot area. Cottongrass and *Sphagnum* cover is developing in restored areas of LWM.
Which *Sphagnum* moss are present?	N/A for the pilot site. There are areas of *S.cuspidatum* and *S.fimbriatum* close by and other parts of LWM that are further along the restoration process have had 11 species mix of BeadaGel™ and BeadaHumok™ introduced.
Recent vegetation survey to form a baseline study?	N/A
Does the site support breeding birds or other key fauna?	Important wintering area for short eared owls and snipe. Breeding curlews and other Red Listed birds found on site. A range of damselfly and dragonfly species.
Peat status and site chemistry	
Current peat depth	Highly variable on the pilot area from 0.8m to just under 2m.
Any bare peat at the site?	Yes approximately 40 Ha
Current peat quality/state of decomposition?	Nutrified top-soil of approximately 30cm. Peat quality is poor and highly decomposed throughout. Von Post scale assessment not yet done.
Physical condition of the peat? loose peat, surface crust, evidence of cracking, wastage, slumping etc?	Peat feels 'gritty' and is either deeply fissured or has a friable surface. There is a fractured surface crust in places. Part of the pilot area (with the shallowest peat layer) retains surface water.

What was the peat formed from?	The most obvious plant remains are grass, heather and wood. Full assessment not yet carried out.
What is the site pH? Are there any minerals present in the peat?	Mean pH = 4. See Appendix 7.5 for full data analysis
Desired state / outcomes	
Desired state and objective for the site	Overall, for LWM the aim is restoration to lowland raised bog with representative plant communities. The aim of this pilot is to establish the best way to achieve the restoration planting needed on bare peat to also reduce carbon GHG emissions most effectively.
What key ecosystem services does it/will the site hopefully support post-pilot?	*Climate:* Conservation of carbon fixed in peat and reduction of CO_2 emissions by rewetting degraded peatlands. Provision of a local cooling effect due to increased water evaporation. *Environment:* Reduction of soil (DOC) run off into ground and surface water from bare peat; renewed function of water purification and water retention in peatlands *Wildlife:* Providing habitats for *Sphagnum* species and associated mossland flora and fauna. *Landscape:* Conservation of open landscape.
Is any site monitoring already undertaken as part of regular surveys or is any planned?	No. Carbon GHG fluxes, with hydrological, meteorological and chemical monitoring are planned as part of the project, alongside vegetation surveys to monitor species cover.

6.0 Design and Methodology

6.1 Location on LWM

A 2 ha area of Little Woolden Moss was identified as suitable to carry out the companion planting pilot, following a site visit between LWT and MMU (see Appendix 7.2 for location).

The area was chosen as it is a good example of the bare peat areas of Little Woolden Moss (left after peat extraction) which have both high-level and low-level areas due to the re-profiling work carried out to fill in the drainage ditches left by peat extraction activities

Site preparation carried out in advance of the Care-Peat pilot (not part of Care-Peat) included the creation of a bunding network across the SW corner of LWM to improve the hydrology of the area and the planting of a shelter belt woodland parallel to the site to protect it from wind.

6.2 Planning

The methodology and experimental design for the companion planting pilot was discussed by colleagues at MMU and LWT during the planning stage. The methodology was partially designed using results of prior research by MMU PhD student Anna Keightley on nearby Cadishead Moss, and also based on experience gained from previous restoration planting work on other parts of LWM by LWT.

6.3 Planting Options

The following three companion planting options were originally proposed to be studied:

1. Common cottongrass plugs with *Sphagnum* plugs added after a 6-month period
2. 75% common cottongrass and 25% Hare's-tail cottongrass plugs with *Sphagnum* plugs added after a 6-month period.
3. Common cottongrass plugs and 'bog in a box' (these are an approach being trialled by LWT consisting of small containers planted with bog species and cultivated off-site to enable planting of well-established plants in order to speed up plant coverage in restoration work).

Following conversations with project partner University of Orleans, it became clear that due to the monitoring resource constraints of the project, it will only be possible to measure one of these approaches and a control area.

It was decided that option 2 together with a control area of bare peat would be piloted. This decision was based on a review of existing research on peatland re-vegetation and the following factors:

- Time taken for vascular plants to establish to give the *Sphagnum* the protection and microclimate to survive.
- To minimise GHG emissions especially the potential methane spike suggested (this will be monitored).

It is recognised that research into the other planting approaches would be useful for comparison and establishing long-term best practice.

However, we will be able to investigate the original planned outcomes as set out in section 3.0 for this form of companion planting against the option of re-wetting the bare peat site and allowing it to re-vegetate through natural re-colonisation, which is sometimes the approach taken on former extraction sites. The pilot will also gain information about the hump/hollow effect on re-vegetating and GHG fluxes; again, useful, applicable data for this particular type of peat restoration site.

See Appendix 7.3 for pilot site planting approach.

6.4 *Sphagnum* choice

The pilot will use a five-species peat-forming mix of *Sphagnum*, recommended by sub-partner Micropropagation Services Ltd (MPS, also known as Beadamoss®), who are providing the *Sphagnum*.

The species used will be the MPS peat-forming SBHYP mix of

- *S. capillifolium* (30%)
- *S. palustre* (30%)
- *S. papillosum* (30%)
- *S. medium/divinum* (5%)
- *S. subnitens* (%5)

This mix has a variety of hummock-forming species, which have greater resistance to decomposition and adaptions to drier conditions than other species. Once fully covering the peat surface, we anticipate these species will maximise carbon storage.

6.5 Timing

Planting of cottongrasses will be carried out in spring 2020 with the *Sphagnum* introduction 6 months later.

6.6 Monitoring

We will be undertaking monthly monitoring of methane and carbon dioxide fluxes, along with environmental variables such as water table depth (WTD), soil temperature and photosynthetically active radiation (PAR). Also, a continuous WTD logger is installed in one of the pilot site dipwells. A micro 'weather station' is already in place in another area of the site, which monitors peat temperature, air temperature, relative humidity, PAR and rainfall every 15 seconds.
We will be looking particularly at rates of *Sphagnum* growth within the established cottongrass mix compared to the control plots, and any suggested influence on carbon GHG fluxes.

The monitoring collars will be sited on higher and lower ground. This will give variation to the data as they will have different water table depths and probably different peat quality (assuming the raised areas were peat-extraction beds and the hollows were filled-in ditches). This should enable the pilot to look at how this variation affects vegetation growth, whether S*phagnum* growth is supported, what happens when hollows flood and any topographical influence on GHG fluxes.

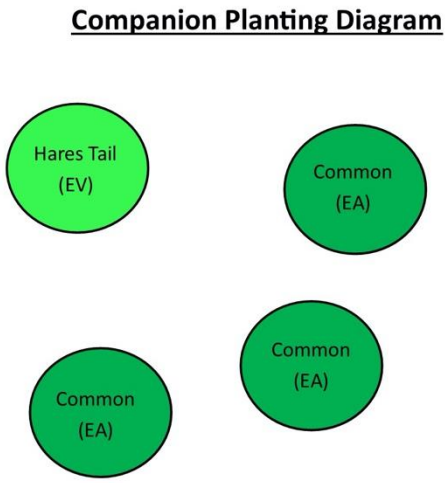
See Appendix 7.4 for the monitoring approach plan.

7.0 Appendix

7.1 Location of Little Woolden Moss

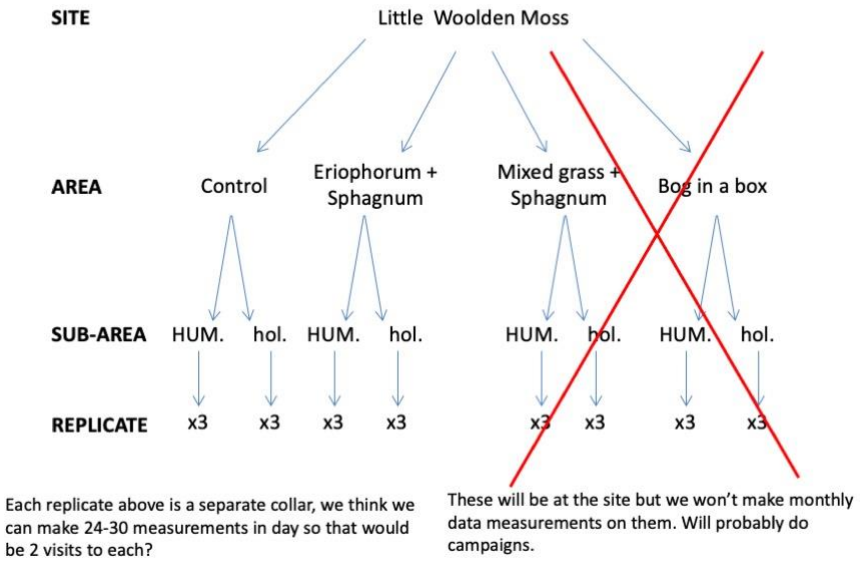
7.2 Location of pilot site on LWM

7.3 Companion planting diagram



The three common cotton grass were planted in such a way as to work as a protective barrier or shield from the

7.4 Monitoring approach



7.5 Chemical Data Table

Elements (DW)	Hollow	Hummock	Elements (mg/l)	Soil water
Nitrate mg/kg	0.71 ± 0.96	0.54 ± 0.29	Chloride	3.1043
Ammonium mg/kg	4.75 ± 3.23	6.61 ± 2.82	Nitrite	0.2365
Nitrogen (%)	1.03 ± 0.07	1.13 ± 0.14	Sulphate	2.0406
Carbon (%)	51.73 ± 2.45	51.85 ± 1.83	Nitrate	0.4136
C/N ratio	50.40 ± 2.89	46.40 ± 5.97	Phosphate	2.0698
FW/DW Ratio	0.22 ± 0.10	0.19 ± 0.03	Ammonium	1.814

DW = dry weight. Values are mean ± SD

Site	pH	LOI %	C %	N %	C/N	Ammonium (mg/kg)	Magnesium (mg/kg)	Calcium (mg/ kg)	Nitrate (mg/kg)	Phosphate (mg/kg)	Sulphate (mg/kg)	Total inorganic N (mg/kg)
LWM Hummock 1	3.93	97.56	53.94	1.08	50.04	59.77	0.00	234.33	2.19	0.00	6.21	46.98
LWM Hummock 2	4.05	95.28	51.03	1.29	39.51	18.51	0.00	158.40	3.34	0.00	0.17	15.15
LWM Hummock 3	4.06	97.35	50.57	1.02	49.63	24.87	214.50	128.87	2.57	0.00	0.15	19.92
LWM Hollow 1	4.08	98.47	54.05	1.03	52.71	53.10	105.57	99.26	1.10	0.00	0.68	41.55
LWM Hollow 2	4.12	95.72	51.96	1.1	47.15	20.25	50.65	77.63	2.36	0.00	0.92	16.28
LWM Hollow 3	3.76	91.76	49.17	0.96	51.33	7.29	2249.68	145.90	3.62	0.00	0.14	6.49