PEATLANDS & HYDROLOGICAL CHANGE

IMPACTS OF FOREST-TO-BOG RESTORATION ON BLANKET BOGS AT PEN Y CYMOEDD WIND FARM, SOUTH WALES

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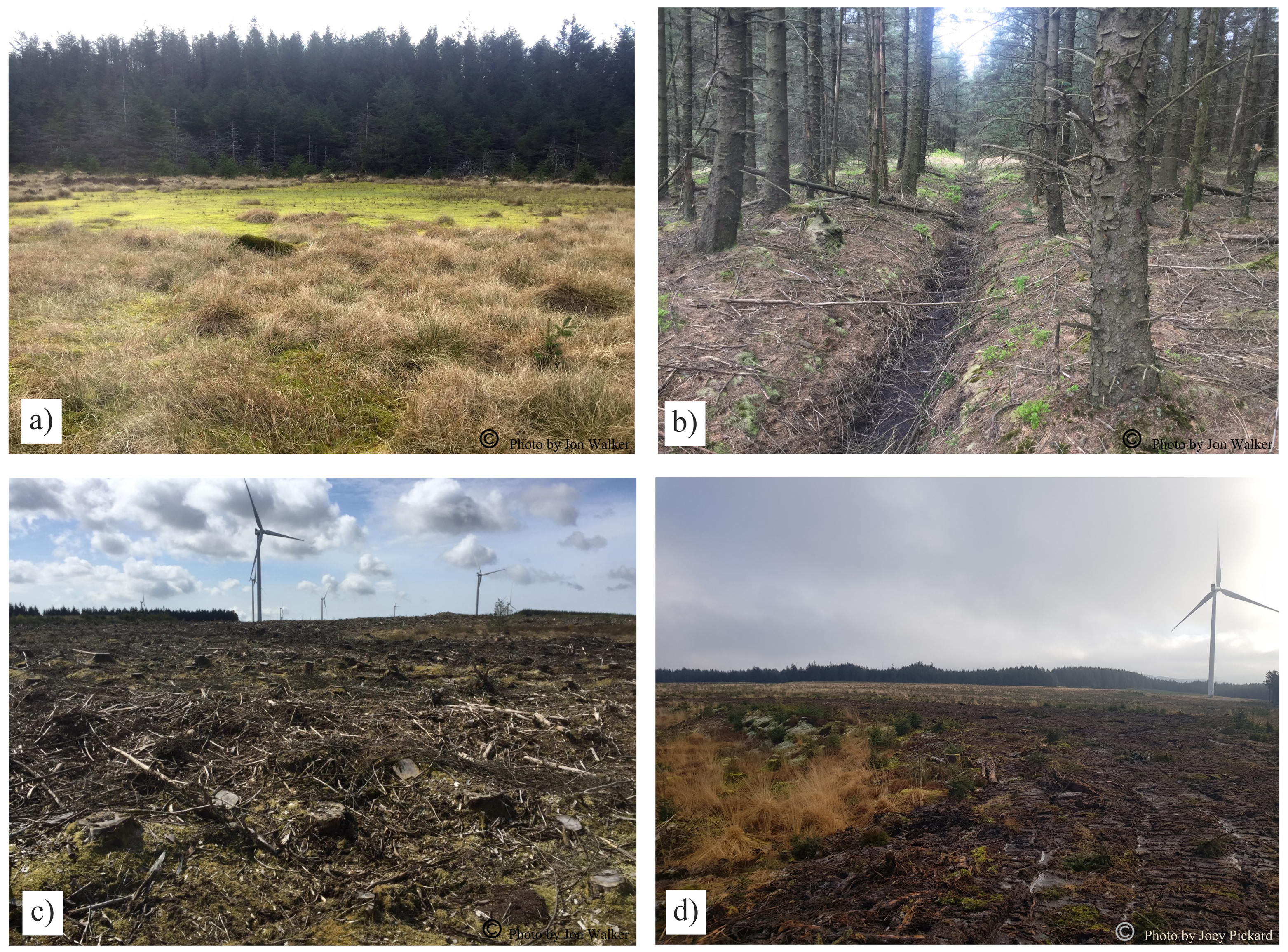
Abstract

Hydrology plays an important role in maintaining peatland functionality. Water table dynamics influence the growth of carbon-capturing peat flora such as *Sphagnum* mosses and determine rates of organic matter accumulation and decay by creating anoxic conditions. Land use changes, including **afforestation**, drainage, and other agricultural activities, result in **unfavourable hydrological conditions** that can reduce biodiversity, increase fire and flood risk, and inhibit peat-forming processes that capture and store atmospheric carbon (Charman, 2002).

This poster proposes research methods to tackle the question of how restoration efforts (‘**forest-to-bog**’ **restoration**) impact subsurface hydrology, and what this means for the **long-term ecohydrological functioning** of peatlands. The **geophysical and field-based data** collection techniques will be used to **parametrise a hydrological peat model** using DigiBog software. The outputs will be valuable for land use management and policymaking and for gauging the success of forest-to-bog restoration.

Study site

The UK’s highest altitude windfarm, **Pen y Cymoedd,** is located on the **ombrotrophic (blanket) peat bogs** of Neath Port Talbot and Rhondda Cynon Taff, which alike to many peatlands across the country, have been modified by the rise of coniferous forestry developments during the 1960’s (Anderson & Peace, 2017). ‘**Forest-to-bog**’ **restoration** efforts are currently underway in attempt to re-establish peatland productivity and ecosystem functionality. One emerging restoration technique is ground-smoothing, where tree stumps are excavated and flipped, then the area is flattened by mechanical cross-tracking (Figure 1d).



Figures 1(a-d): Four states of peat at Pen y Cymoedd: a) intact (foreground), b) afforested, c) felled, and d) restored (stump-flipping/ ground-smoothing method).

Data collection methods

Dip wells

Dip wells can measure a variety of hydraulic measurements, including the **hydraulic conductivity (*K*)** and **drainable porosity (*s*)**.

- **Piezometers:** these devices may be left in a dip well to monitor **water table** levels. They can also measure the pressure of liquid diffusion, revealing hydraulic gradients.
- **Slug tests:** these can also be used to calculate hydraulic gradients by measuring the response to a forced change in the well head, which is induced by inserting or removing a volume (the slug).

Table 1: Suggested *K* and *s* values to use in blanket peat models (Baird, Gill & Young, 2020). We would expect to obtain similar values in our field-based measurements.

Part of peat profile	Hydraulic conductivity, *K* (cm s^{-1})	Drainable porosity (*s*)
Upper 5 cm	0.0005 – 0.2 (proximal) 0.0002 – 0.0015 (distal)	0.3 – 0.5
5 – 10 cm	0.000015 – 0.0018	0.2 – 0.3
20 – 30 cm	0.000015 – 0.0007	0.1 – 0.3
50 – 140 cm (and deeper)	0.000001 – 0.00016	0.05 – 0.1

Ground-penetrating radar (GPR)

GPR surveys can **estimate peat thickness** and **define basal topography** by measuring the **velocity of electromagnetic wave reflection**. Consisting of an emitting and receiving antenna and a control unit, GPR systems may be ground-based (Figure 2) or airborne (Figure 3). As opposed to manual depth-probing, a geophysical approach is minimally invasive and less time and resource-intense (McClellan *et. al*., 2017), although probing remain a valuable tool for reducing uncertainty (Parsekian *et. al*., 2012).

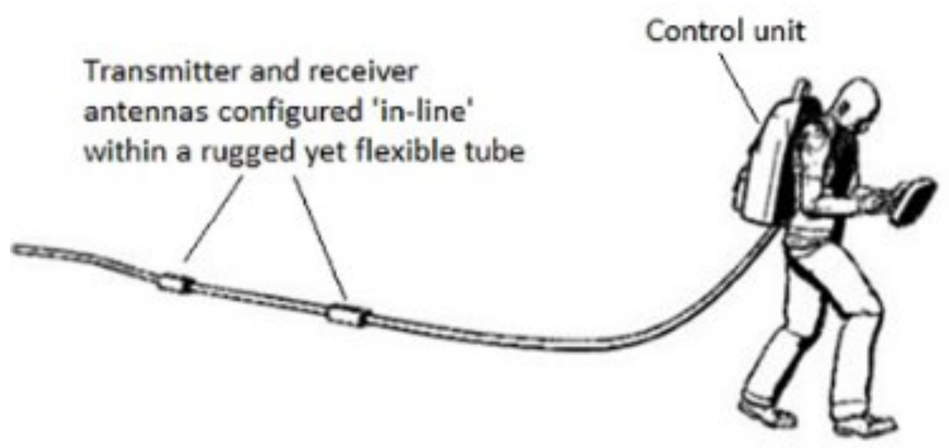


Figure 2: Illustration of a rough-terrain GPR system (Carless et. al., 2021).

Figure 3: Drone at Swansea University ready to be flown.

Self-potential surveys (SP)

SP surveys measure **natural subsurface voltages** as the difference in currents between two or more electrodes. Since groundwater flows drag ionic charges, they produce a (streaming) electrical current, and therefore SP data can be used to map **preferential fluid-flow pathways** (Ikard *et. al*., 2012).

In July, we trialled an SP survey profile crossing both intact and afforested peat. Results were mapped using QGIS (Figure 4). Positive voltage anomalies clearly correspond with the open, intact peat areas, leading to the assumption that these regions have a higher permeability and hydraulic conductivity (*K*).

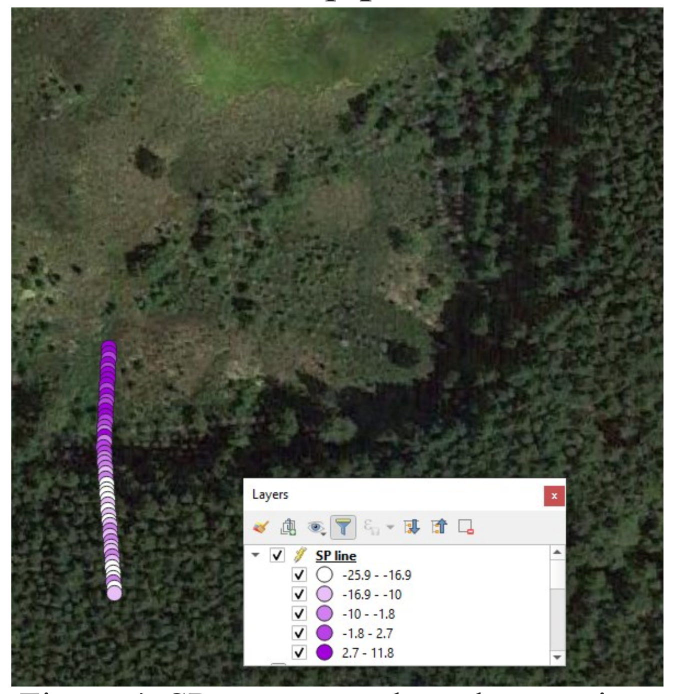


Figure 4: SP survey conducted across intact and afforested peat at Pen y Cymoedd, 29/07/22. Purple shades represent positive/ negative anomaly gradient of millivolts.

DigiBog_Hydro model

A hybrid mathematical & conceptual model that simulates the subsurface behaviour of water (Baird *et. al.,* 2012).

4 peat scenarios will be modelled:

- Intact
- Afforested
- Felled
- Restored

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