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Restoration of a conifer plantation to lowland raised bog at Cors-y-Sarnau

REPORT

Restoration of a conifer plantation to lowland raised bog at Cors-y-Sarnau

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Summary

Cors-y-Sarnau is a nature reserve in North Wales with a variety of wetland habitats on deep peat deposits. This includes an area of former conifer plantation that was identified as having potential for rewetting and recovery of the underlying peatland.

Approximately 5 ha of peatland has been cleared and rewetted as part of the Care-Peat project. The restoration works had to overcome the challenges of working with a former forestry site, where forestry operations had left behind an uneven and heavily modified bog surface with large numbers of remnant tree stumps. Data collected during the project provided a new interpretation of the site hydrology and helped to guide the restoration measures.

Initial results indicate that ground water levels are starting to rise and stabilise across the restoration area. Ponds created during the restoration works have attracted a range of invertebrates and provided a boost to biodiversity on the site. Wetland and heathland plants that survived within the forestry have started to spread, although ongoing management will be required to keep grasses and heather in check.

Description of site

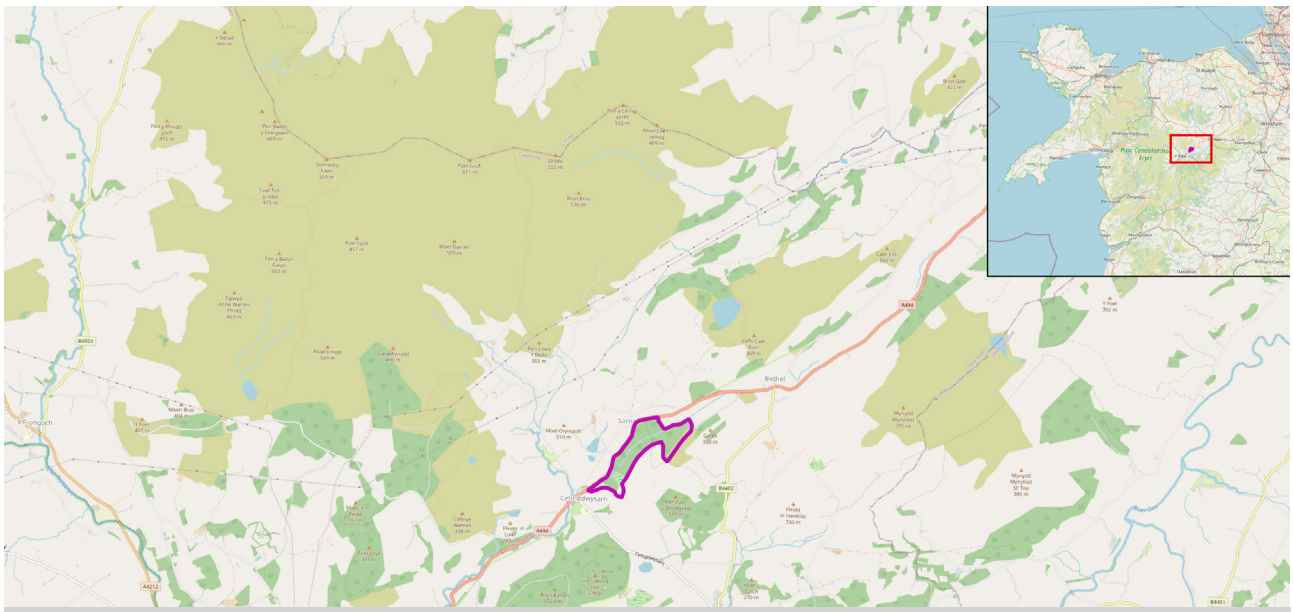


Figure 1.1: Map of the location of the Cors-y-Sarnau pilot site.

Cors-y-Sarnau is a local nature reserve located near to the town of Bala in Gwynedd, North Wales, which has been managed by the North Wales Wildlife Trust (NWWT) since 1972. Situated in a landscape dominated by agricultural grassland, Cors-y-Sarnau is a low-lying peatland that has accumulated in post-glacial depressions. The Cors-y-Sarnau Site of Special Scientific Interest (SSSI), which forms the basis for the original reserve, covers approximately 14 ha. A block of conifer plantation adjacent to the Cors-y-Sarnau SSSI, known as Coed Tŷ Uchaf, was added to the reserve in 2014 and covers a further 14 ha. A key feature of Cors-y-Sarnau is a partially-engineered stream which flows southwest through the reserve and acts as the main drainage channel for the site.

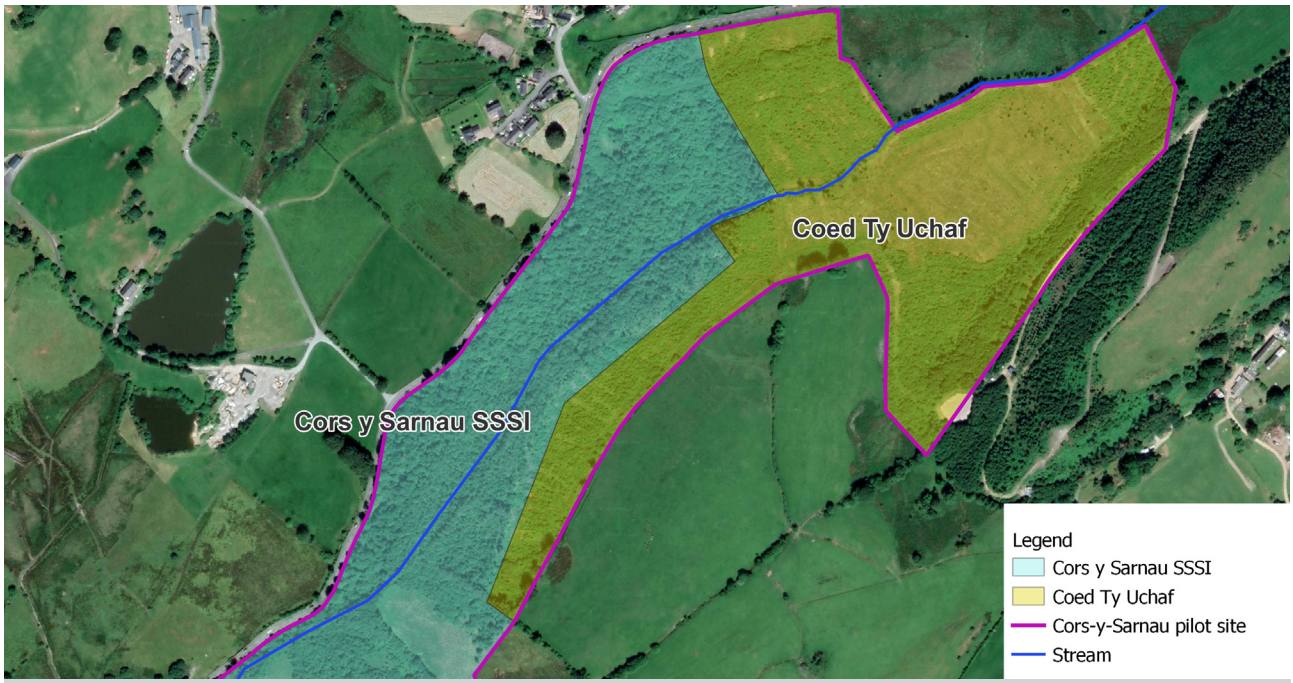


Figure 1.2: Map of the Cors-y-Sarnau pilot site and internal subdivisions.

The Cors-y-Sarnau SSSI is dominated by alder woodland on deep peat deposits that occupies the lowest-lying section of the reserve, with a mosaic of smaller areas of open fen and mire. Over 130 species of mosses, liverworts and lichens have been recorded from Cors-y-Sarnau, and the site is also important for a range of invertebrate species, including three nationally rare and 30 regionally or locally important species of crane-fly.

Figure 1.3: Wet woodland in the Cors-y-Sarnau SSSI.

Coed Tŷ Uchaf occupies the valley floor upslope of the Cors-y-Sarnau SSSI, with a narrow strip extending southwest above the SSSI. Most of the available data for Coed Tŷ Uchaf comes from two reports commissioned by NWWT in early 2013, when the area was covered by a conifer (Sitka spruce) plantation. These initial surveys found peat depths in excess of 3 m on parts of Coed Tŷ Uchaf, and winter groundwater levels were generally within 20 cm of the surface.

Flora recorded during the initial surveys indicated that remnant mire or bog communities were present in the plantation understory; species included hare's-tail cottongrass (*Eriophorum vaginatum*), bilberry (*Vaccinium myrtillus*), heath (*Calluna vulgaris*), purple moor-grass (*Molinia caerulea*) and a range of Sphagnum species (*S. capillifolium, S. magellanicum, S. recurvum, S. fallax* and *S. palustre*). It was also noted that the field immediately north of Coed Tŷ Uchaf is at a similar height with respect to the drainage channel and contained a wetland mire community.
The conifer plantation at Coed Tŷ Uchaf was felled in 2016, and subsequently recolonised by a dense stand of young trees dominated by birch (*Betula sp.*). The deeper areas of peat have been damaged by a cross-cutting network of ditches, grips and forestry furrows, some of which were partially blocked with brash during the removal of the conifers. While no historic hydrological data was available, it was observed that the central areas of the peatland were dry and degraded.

Figure 1.4: Coed Tŷ Uchaf restoration area during the clearance of conifers in 2016.

The Care-Peat project aimed to restore peatland across Cors-y-Sarnau, with around 8 ha of deep peat on Coed Tŷ Uchaf considered suitable for rewetting. The project needed to account for how the remnants of the previous forestry operations – including tree stumps and a very uneven and complex topography – would affect the restoration plans. The other objective of the project was to consider how the restoration works would impact the existing habitats and flora on the site, and seek ways to maximise biodiversity gains.

Restoration works

2.1 Introduction

The restoration works were designed to balance maximising the ground water levels and stability, whilst minimising the impact on the habitats and wetland flora already present in Coed Tŷ Uchaf. Restoration efforts have focussed on the areas of deepest peat, which have the most degraded peat but also the most diverse remnant wetland flora.

2.2 Scrub clearance

Approximately 5 ha of scrub has been cleared from Coed Tŷ Uchaf, focussing on the area of deepest peat (3-6 m peat depth) to the south of the stream. Due to the very uneven ground surface, with remnant tree stumps and numbeous ditches, the use of machinery was ruled out and the clearance was carried out by hand. This also had the advantage of minimising the disturbance and destruction of any wetland plants that remained on the site.

The scrub was cleared by experienced contractors using a combination of chainsaws and brush cutters; clearance saws proved to be far more effective than regular brush cutter blades. The clearance works generated large volumes of brash which, in order to maximise the time available to the contractors, was left in situ to be dealt with at a later date by volunteers. While some brash was burnt on site, this should be seen as a last resort due to the associated carbon emissions. Instead, the majority of the brash was used to create dead hedges and brash piles along the edge of the peatland, with a small amount broken up further and used to partially block larger ditches.

Widespread herbicide treatment of the scrub was avoided due to the labour and costs involved, and the risk of damage to wetlands sensitive habitats. This means that scrub has continued to regenerate on the restoration area, and has to be managed by contractors and volunteers. Spot-treatment of regenerating trees in the most sensitive areas is being carried out, and regeneration across the site should slow as water retention is improved.

Figure 2.1: Birch scrub was cleared from the restoration area by hand in winter 2021/2022, with brash left behind for later removal.

2.3 Topographic and hydrological surveys

Initial surveys had identified that peat within the restoration area was drying out, and most likely failing to retain sufficient groundwater year-round, and it was therefore critical to understand the water flow on the site. Dipwells were installed in the restoration area, but with a complex drainage network and a lack of baseline data, additional data was sought which would identify the key areas for intervention in order to maximise water retention.

Existing aerial imagery was low resolution and obscured by tree cover. A drone survey was therefore carried out to produce a high resolution orthomosaic image of Cors-y-Sarnau which could be used to identify ground features (such as ditches) and general habitats; this method was both rapid and cost-efficient, and saved significant time in comparison to surveying the features on the ground. A Digital Surface Model (DSM) was also created from the drone data using photogrammetry. While it was not possible to create a true Digital Elevation Model (DEM) using this technique, the results closely approximated the ground surface in areas where vegetation had been cleared and there was a significant cost-saving in comparison to commissioning a LiDAR survey.

The data collected from the drone survey was used to support a hydrological assessment of the restoration area. The DSM proved critical for understanding the hydrology of the site as many features could not easily be picked out on the ground, such as the cross-cutting relationship between ditches or subtle variations in their elevation. The initial assumuption had been that the main part of the restoration area, where the deepest peat is present, was a mire fed by water flowing through it from the slopes to the south and south-east. However, the hydrological survey identified several anomalies that challenged this assumption:

- The area where the deepest peat is present is actually a series of subtle, low-relief domes, with ditches orientated in all directions. In some cases, continuous ditches cut across a local watershed within the restoration area, with water flowing in opposite directions within the same ditch.

- Drainage ditches entering Coed Tŷ Uchaf from adjacent fields skirt around the edges of the deeper peat rather than cutting through it. Run-off therefore cannot be the main water supply for the peatland, and it must be predominantly rain-fed.

- While water was present in the larger ditches, flow rates were very low. Surface connections to the stream also could not be identified in the main restoration area. Water loss is thought to be mainly through groundwater seepage or hidden/buried ditches, driven by a large hydrostatic gradient between the top of the peat domes and the adjacent stream.

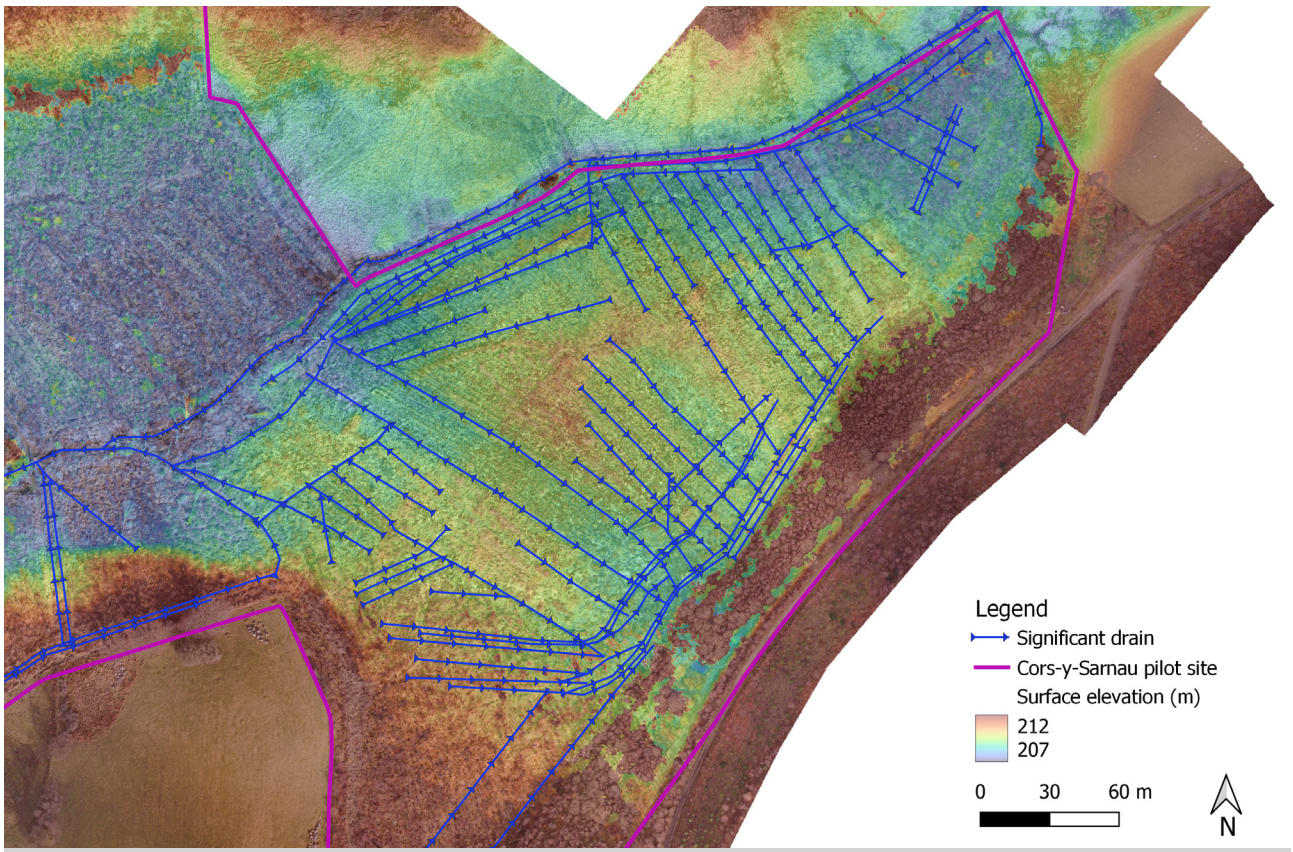


Figure 2.2: Significant surface drainage pathways were identified using a Digital Surface Model and an orthomosaic image of the restoration area (overlain here), supported by fieldwork to determine flow direcions.

With this new hydrological information, the model of the main restoration area was refined from being a mire to being a remnant raised bog, and the restoration plan had to be modified accordingly. As subsurface flow had been identified as the main cause of water loss from the bog, blocking the larger ditches would have a limited impact on flow rates, and would not address the high hydrostatic gradient.

The proposed solution was to install a low-profile contour bund along the north-eastern edge of the main restoration area, a technique which is more commonly used in upland settings to slow water flow over bare peat. The use of a bund has the advantage of creating a continuous flow barrier which removes any cracks, root zones or hidden ditches that would otherwise allow water ground water to bypass dams. An added benefit is that as the bund is raised slightly above the current surface of the bog it will increase the volume of rainwater that can potential be stored. The goal is to raise water levels across the restoration area, with the water table ideally remaining within 30 cm of the surface year-round in order to keep the peat saturated.

2.4 Hydrological repair works

2.4.1 Groundworks

The groundworks were carried out by a contractor with significant experience of peatland restoration, including the creation of contour bunds. Two low-pressure excavators were used for the restoration works, each with a footprint of approximately 13.8 kPa two excavators allowed the works to be carried out in parallel, but also provided a back-up to allow recovery should one machine become stuck. Bog mats were also brought to site, to both reduce ground pressure and damage to waterlogged ground. However, as the works were carried out during an unseasonally prolonged dry spell the bog mats did not need to be used.

Both excavators were fitted with tilt-and-rotate couplers which allow 360° movement of the excavator bucket. These allow the operators to work more efficiently, with less repostioning of the machinery. A bunded fuel cube was also transported to site to allow refuelling close to the restoration area, saving time and additional potentially damaging movement across the site.

Figure 2.3: Excavator creating a section of bund, using a tilt-and-rotate coupler to increase the freedom of movement of the excavator bucket.

2.3.2 Bund design and specifications

The low-profile contour bund was designed to enclosing the area of deepest peat, parallel to the slope of the bog surface and following the contour as close as possible (through a combination of topographic maps, GPS, and operator experience) so that there is minimal change in elevation along its length. Shorter cross-bunds are spaced approximately every 20 m and roughly perpendicular to the slope to create smaller cells; these reduce the pressure of surface water pressure on the bund, reducing wave fetch and therefore potential wave damage in each cell, and minimise the amount of water loss should a section of bund fail.

The bund is keyed into the peatland to ensure that water cannot pass through it, or flow underneath it through degraded pear or subsurface cracks. A trench is excavated to approximately 1m below the existing surface, going lower where it has to cross ditches or if peat cracks are found. The excavated peat is then mixed and relaid, and compacted to form the bund. Additional good quality peat is gained from borrow pits created on the upslope side of the bund.

The completed bund is approximately 0.8 m wide and raised to 0.25 m high relative to the bog surface. Vegetation is replaced on the top of the bund to help provide protection to the structure. Tree stumps along or adjacent to the bund position are dug out during the bund construction and placed upside down into the borrow pits.

Figure 2.4: Newly completed bund, recovered with vegetation. The borrow pit created to source good quality peat for the bund is in the foreground, and has already started to fill with groundwater.

Figure 2.5: Detail of a completed section of bund, recovered with vegetation. The borrow pit is situated to the left of the bund and has been partially filled with brash and spare vegetation.

2.3.3 Scrapes and ponds

Nutrient run-off from adjacent fields was identified as a potential negative influence on the peatland habitats at Cors-y-Sarnau. While the hydrological survey had determined that water from the fields was unlikely to be entering the main restoration area, it was flowing around the edges and towards the Cors-y-Sarnau SSSI. In order to reduce the nutrient influx, four ponds were designed along the southern edge of the restoration area, in positions where ditches and groundwater from the fields were believed to be entering Coed Tŷ Uchaf. In addition to intercepting nutrient-rich waters, the ponds will provide additional habitats on site and increase biodiversity.

Each of the ponds consists of a wide, flat scrape created by removing the vegetation and surface peat to create a flatter area slightly below the existing bog surface. At the centre of each scrape, a pond is excavated up to 1 m deep and left to fill from the water table. This design means that the deeper areas of the pond should retain water year-round, while the scrapes will become revegetated and will be seasonally indundated. Excavated material is used to block adjacent ditches or create shallow banks on the downslope side of each pond to help with water retention.

While the ponds and scrapes are expected to naturally revegate, following the groundworks volunteers relocated small numbers of *Sphagnum cuspidatum* and bulrushes (*Typha*) to the edges of the ponds from elsewhere within Cors-y-Sarnau to help speed up the process.

Figure 2.6: Newly completed pond, the deeper central section (partially filled with groundwater) is surrounded by a wide scrape.

Figure 2.7: One of the ponds three days after creation, with water spreading onto the scrape and flooding back up an adjacent drainage ditch.

Monitoring and Restoration Outcomes

3.1 Hydrology

Water levels are being monitored at dipwells across the site, although with baseline data and only a short monitoring period post-intervention, the results are limited at present. Weather conditions have also fluctuated widely through the monitoring period with extremely dry weather followed by long periods of heavy rain, while affects interpretation of the data. Ongoing hydrological monitoring will add to the data set and build up a longer term understand of the response to the groundworks.

The initial data shows that average water table depths have risen by approximately 9 cm across the restoration area in comparison to measurements taken in the same period but prior to the groundworks. Additionally, the average water table depth only exceeded 30 cm during a period of drought in June 2023. The monitoring data has also been split into three hydrological compartments; the main restoration area and two areas immediately to the east and west which are thought to be beyond the immediate influence of the bund. Each of the areas have seen the average water table rise in comparison to the same period in the previous year, but unexpectedly the largest increases have been in the western area, positioned at the base of slope above the ponds. The data also suggests that there is further internal compartmentalisation of ground water within the restoration area as changes in the ground water levels are uneven across the site.

	Ground water depth below surface (cm)												Site average water depth below surface (cm)
	Western area			Main restoration area						Eastern area			
September 2022	13	66	35	10	25	17	32	2	35	50	1	15	25,08
April 2023	0	36	17,5	0	28	12	30	0	25,5	43,5	0	0	16,04
May 2023	No data			No data - restoration area widely flooded						No data			No data
June 2023	14,5	60,5	45	29	33,5	26	43	20	35,5	53,5	19,5	20,5	33,38
July 2023	No data	47	29	8	30,5	15	29	25	30,5	21	11	13	23,55
August 2023	5	38	30	7,5	30	14,5	25	0	29	43	5	8	19,58
September 2023	1,5	34,5	16	4,5	25,5	11	28	0	27	40,5	2	5	16,29
Annual change	11,5	31,5	19,0	5,5	-0,5	6,0	4,0	2,0	8,0	9,5	-1,0	10,0	8,79

Table 3.1: Results of monitoring of ground water levels across Coed Tŷ Uchaf. Hydrological repairs were completed in March 2023. Water levels within 30cm of the surface are coloured blue.

One of the challenges with monitoring the water table at Coed Tŷ Uchaf is the height difference between the ridges and ditches making up the surface of the bog, which can be up to one metre. Dipwells have therefore been positioned in both hollows (ditches and depressions) and on hummocks (ridges and plateaus). Water table levels in the hollows have remained within 30 cm of the surface year-round, even during the drought period in June 2023. Water levels have risen more in the hollows on the edges of the restoration area, which may be linked to the presence of the ponds and the bund propping up the water table in areas beyond its physical limits. Groundwater levels have varied widely on the hummocks, although promisingly have been most stable within the main restoration area, staying close to 30 cm from the surface.

	Ground water depth below surface (cm)											
	Hollows						Hummocks					
	West	Restoration area			East		West		Restoration area			East
September 2022	13	10	17	2	1	15	66	35	25	32	35	50
April 2023	0	0	12	0	0	0	36	17,5	28	30	25,5	43,5
May 2023	No data - restoration area widely flooded						No data - restoration area widely flooded					
June 2023	14,5	29	26	20	19,5	20,5	60,5	45	33,5	43	35,5	53,5
July 2023	No data	8	15	25	11	13	47	29	30,5	29	30,5	21
August 2023	5	7,5	14,5	0	5	8	38	30	30	25	29	43
September 2023	1,5	4,5	11	0	2	5	34,5	16	25,5	28	27	40,5
Annual change	11,5	5,5	6,0	2,0	-1,0	10,0	31,5	19,0	-0,5	4,0	8,0	9,5

Table 3.2: Comparison of ground water levels in hollows and on hummocks. Water levels within 30cm of the surface are coloured blue.

While no long-term patterns have yet emerged the general observation is that ground water levels within the central part of the restoration may have risen slightly and seem to be stabilising at a higher level compared to pre-intervention levels. The monitoring results also suggest some compartmentalisation of the ground water, with notable variations in the ground water levels between some adjacent dipwells. Direct observations of the bund have also shown that it is functioning well, with water pooling to the top of the bund in many places - 20 cm above the existing bog surface – following periods of heavy rainfall. Surface water has also been observed pooling back up the ditches and spreading onto low-lying areas of the bog, a further indication that the volume and duration of water retention has been improved through the installation of the bund.

Figure 3.1: Water pooling behind the bund following heavy rain.

Figure 3.2: Completely flooded borrow pit, with the water approaching the top of the bund and flooding back up ditches and over the bog surface.

3.2 Progression towards conservation goals

The habitat in the restoration area is a complex mosaic of scrub, wet and dry heath, marshy grassland and bog/mire communities, strongly influenced by the uneven topography left behind by former forestry activity and variations in groundwater levels. The topography and remnant wetland plant communties indicate that Coed Tŷ Uchaf used to be a raised bog and therefore increasing the proportion of this habitat is the main conservation goal for the site. However, the other habitats also have biodiversity benefits and it is envisioned that Coed Tŷ Uchaf will move towards a mosaic of raised bog and wet heath, transitioning into grassland and dry heath towards the margins. Annual vegetation suveys are being undertaken to track changes to the habitats.

There are many positive signs that recovery of bog and wet heath will be possible, with several wetland species found to still be present when the scrub was cleared; notable plants include hare's-tail cottongrass (*Eriophorum vaginatum*), cross-leaved heath (*Erica tetralix)*, cranberry (*Vaccinium oxycoccos*), crowberry (*Empetrum nigrum*) and a range of sphagnum species. With the scrub cleared, the cover of heath species has increased, which is preferable to tree cover but may require future management. As water levels rise and the ground becomes more saturated it is hoped that scrub regeneration will be reduced, and there are already some signs that birch regrowth has slowed in rewetted areas. For future management of scrub and grasses, infrastructure has been put into place to allow conservation grazing on Coed Tŷ Uchaf, with a view to introducing Carneddau ponies to the site in early 2024.

One of the biggest immediate successes of the Care-Peat project at Cors-y-Sarnau has been the newly-created ponds. The scrapes have already been partially colonised by bulbous rush (*Juncus bulbosus*), a species that had not previously been recorded on the site. The ponds have also attracted a range of invertebrates, such as pond skaters (*Gerris lacustris*), whirligig beetles (*Gyrinus substriatus*), water boatmen and diving beetles. Common blue damselfly (*Enallagma cyathigerum*) and at least four species of dragonfly have also been observed around the ponds, with the latter seen laying eggs in the water.

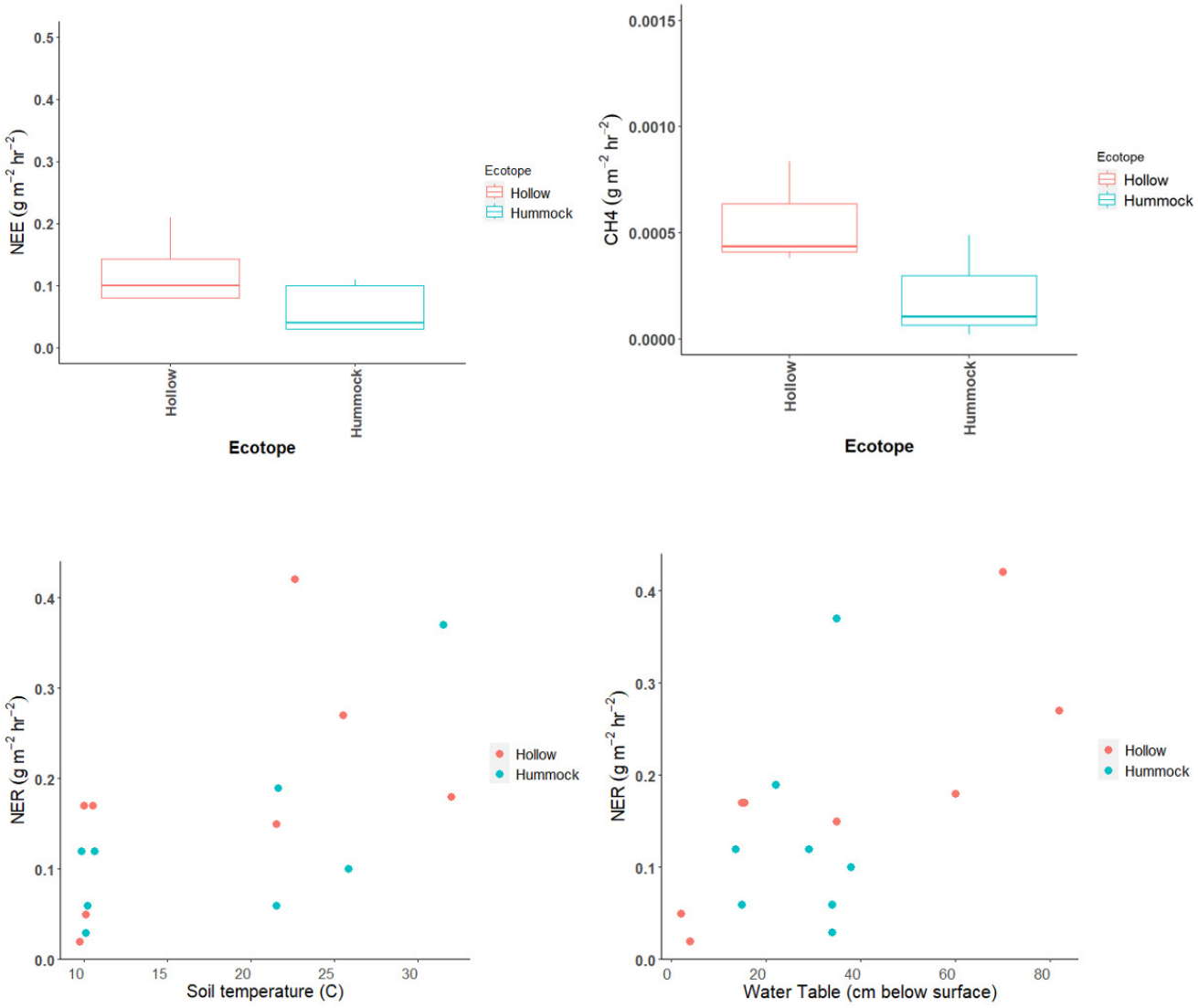
Figure 3.3: Partially-flooded scrape recolonised by soft rush (Juncus effusus) and bulbous rush (*Juncus bulbosus*).

Figure 3.4: Broad-bodied chaser (*Libellula depressa*), one of several species of dragonfly now present on Coed Tŷ Uchaf and observed laying eggs in the new ponds.

3.3 GHG Monitoring

Eight Greenhouse Gas (GHG) monitoring locations were established across the site in pairs of hummocks and hollows; the hummocks on ridges where trees were planted prior to felling, the hollows in former drainage gulleys blocked by restoration. Dipwells of 6 cm diameter were installed at each monitoring location to monitor water table. Data was been collected on two occasions, a very hot day in summer 2022, and a cool, cloudy day in spring 2023.

Net fluxes of CO_2 (NEE – Net Ecosystem Exchange) were slightly higher in the former blocked gulleys as were methane fluxes (CH4), though in both cases differences were marginal and overall fluxes were very low. Relationships between CO_2 release (NER – Net Ecosystem Respiration), soil temperature and water table have begun to emerge, highlighting that as water tables rise following restoration CO_2 losses will reduce further. Methane losses were not linked to any environmental variable.



Stakeholder engagement

4.1 Introduction

The involvement of stakeholders has been important to the success of the Care-Peat project at Cors-y-Sarnau, both in terms of delivering the restoration work and spreading the message of the benefits of peatland restoration. Natural Resources Wales (NRW) have been a key stakeholder for the project. NWWT have also reached out to other bodies and NGOs with responsibilities for peatlands in North Wales, and an interest in peatland restoration or similar projects of their own. Volunteers have been critical for helping to carry out the restoration works, and will continue to be important for monitoring and future management of the site.

4.2 Stakeholder organisations

NRW were the most important stakeholder organisation for the Care-Peat project at Cors-y-Sarnau. In addition to having a regulatory role over our management of the protected (SSSI) parts of Cors-y-Sarnau, NRW were able to provide match-funding for some aspects of the restoration works through their National Peatland Action Programme (NPAP) and a land management agreement. Furthermore, the NPAP team were able to review and provide feedback on the restoration plans for Coed Tŷ Uchaf, particularly the technical specifications, and provide advice on selecting contractors.

Connections were also made with other organisations with interests in peatland restoration or existing projects in North Wales. These included landowners investigating forest-to-bog restoration on conifer plantations or currently working on (generally upland) peatland restoration, and NGOs focussed on specific wetland habitats and species. Themes that came out of these discussions included overlap of geographic areas of interest, reproduction of effort (particularly engagement and research), and a lack of visibility of a ‘bigger picture’ of peatland restoration in North Wales

4.2.1 Stakeholder meetings

On-site meetings were held with NRW and other stakeholders throughout the course of the Care-Peat project. NWWT were also invited by stakeholders to provide input to projects and community engagement events, to help promote peatland restoration and sympathetic management of wetlands. NWWT was also invited to join the Migneint-Hiraethog Peatland Forum, which was established in 2023.

This group connects stakeholder organisations to join up efforts in peatland restoration in southern North Wales, including the region around Cors-y-Sarnau. This encompasses a range of projects and habitats, with a long-term view to identifying gaps in restoration efforts and sharing knowledge on best practices for peatland restoration. Through this forum NWWT have been able to share the progress of the Care-Peat project at Cors-y-Sarnau and seek feedback from local partners, and arrange a site visit to demonstrate the results of the restoration works.

4.3 Volunteers

Volunteers are vital for helping NWWT manage our reserves. Cors-y-Sarnau was a site that only had infrequent volunteer sessions, and often only winter work was carried out. The Care-Peat project has allowed us to establish regular volunteer sessions, with a core group of volunteers now working at the site one a month. The volunteers have been involved in the restoration works and monitoring, and have become advocates for peatland restoration.

Figure 4.1: Cors-y-Sarnau volunteers clearing birch (Betula sp.) from the restoration area at Coed Tŷ Uchaf.

4.4 Local inhabitants and Wildlife Trust members

The area surrounding Cors-y-Sarnau is sparsely populated, although two villages (Sarnau and Cefn-ddwysarn) neighbour the reserve. As significant works, which could potentially be viewed as destructive, contacts in the local community were informed of the restoration plans and invited to meet with the project officer. The owner of land to the north of Coed Tŷ Uchaf, which could be potentially be impacted by the works, has been a key supporter of the peatland restoration within the local community and has visited the project several times. The primary school at Cefn-ddwysarn was also invited to find out more about the Care-Peat project, and a school group was able to visit the site with the project officer to learn about biodiversity and carbon storage potential of peatlands.

The Care-Peat project has also been promoted through the NWWT member network, including social media, newsletters and the 2023 Annual Impact Report. Two public events have been held on NWWT reserves to demonstrate peatland habitats, monitoring and management, and an online public talk was delivered about the Care-Peat project at Cors-y-Sarnau.

Overall conclusion

The Care-Peat project at Cors-y-Sarnau has been a success in terms of carrying out hydrological repairs in a way to balance both peatland restoration and biodiveristy gain. It has been possible to use a low-impact approach, on a site which is degraged but still has many of the components of a healthy wetland flora, to minimise the impact on the existing flora. Early indiciations are that the restoration works are rewetting the site, with ground water levels rising and open water being retained for longer across larger areas of the bog surface.

One lesson from the works at Cors-y-Sarnau is how important it is to tailor the restoration techniques to fit the site; the 'obvious' solution - in this case ditch-blocking – may not be the most effective or efficient. As demonstrated on Coed Tŷ Uchaf, better restoration outcomes might be possible if plans are adapted in light of new data or advice.

Future work

Restoration works will continue at Cors-y-Sarnau for the foreseeable future, with more work to be done collecting and anaylsing data to determine how ground water levels are settling following the restoration works. This may identify areas on the site where additional interventions, such as damming individual ditches, will further improve water retention. Work will also continue in the area north of the stream, where scrub still covers a smaller area of deep peat.

Ongoing management of the vegetation at Coed Tŷ Uchaf will be required; while tree regrowth is expected to diminish as water levels rise, any regrowth will need to be controlled. It will also be important to ensure that purple moor grass (*Molinia caerulea*), bilberry (*Vaccinium myrtillus*) and heather species do not spread at the expense of the rarer wetland plants. Volunteers will continue to help manage the vegetation on the site and a grazing regime, using local Carneddau ponies, will also be introduced to help supress the shrubs and grasses.

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