PROSIECT LIFE+ CORSYDD MÔN A LLŶN
ANGLESEY AND LLŶN FENS LIFE+ PROJECT

LIFE 07 NAT UK 000948

Responses of rich-fen Annex I and related habitats to restoration and management undertaken as part of the Anglesey & Llyn Fens LIFE Project.

(*LIFE* project action E.4.02)

Final Report of the Anglesey & Llyn Fens LIFE Project: Technical Report No. 7.

Version	Draft
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Project title: Restoring alkaline fen and calcareous fen within the Corsydd Mon and Llyn (Anglesey and Llyn Fens) SACs in Wales.

Project Objectives: The objective of this project is to bring 751 ha of fen within the Corsydd Mon/Anglesey Fens SAC and Corsydd Llyn/Lleyn Fens SAC into favourable or recovering condition through measures aimed at tackling the factors adversely affecting their condition and by delivering more sympathetic management.

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Cover photo: Mowing with the tracked Pistenbully (Action C1) at Bryn Mwcog, Cors Erddreiniog, October 2010. All photos P.S. Jones, NRW.

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Annexes

SUMMARY

This report covers LIFE project action E.4.02 and describes the methodology employed to monitor detailed changes in plant and vegetation responses to restoration management applied through the Anglesey & Llyn Fens LIFE project: also presented are the results of monitoring up until 2013. The report complements LIFE Technical Report No. 8 which considers condition monitoring of stands of alkaline and calcareous fen.

Early responses to emerge across all plots that have been the recipients of intensive management operations, principally machine mowing (C1) and hand cutting (C2) include clear reductions in components such as graminoid cover, litter cover, dwarf shrub cover and vegetation height. In addition to which, on plots where they were found, similar reductions have occurred in *Cladium mariscus* and *Molinia caerulea*.cover. All of these are significant prerequisites for attainment of target condition. Indeed, evidence from the paired 'Treatment & Control' plots suggests that early intensive intervention in the form of machine mowing (or similar) is probably essential to allow stock to penetrate the sward.

On the majority of plots, following the initial early reductions, there has followed a year-on-year increasing trend in many of these components. Although, in the majority of cases, this has not resulted in significant year-on-year increases or a return to pre-intensive management operation levels, it serves as a barometer of grazing effect and a potentially useful empirical tool with which to evaluate the intensity of grazing required in order to maintain conditions favourable to sward enhancement.

Indicators such as the cover of positive indicator species, including bryophytes, forbs and slender sedges show a modest response to management, reflecting the inherently low proportional cover of these species this early-on in restoration, and also insufficient time for recruitment and growth.

CRYNODEB

Mae'r adroddiad hwn yn ymdrin â cham gweithredu E.4.02 prosiect LIFE, ac mae'n disgrifio'r fethodoleg a ddefnyddiwyd i fonitro newidiadau manwl mewn ymatebion planhigion a llystyfiant i'r gwaith rheoli adferiad a wnaed drwy brosiect LIFE ffeniau Ynys Môn a Llŷn: cyflwynir hefyd canlyniadau monitro hyd at 2013. Mae'r adroddiad yn cyd-fynd ag Adroddiad Technegol LIFE Rhif 8 sy'n ystyried monitro cyflwr clystyrau o ffeniau alcalinaidd a chalchaidd.

Mae ymatebion cynnar i ymddangos ar draws pob llain lle y bu gweithrediadau rheoli dwys, sef torri â pheiriant (C1) a thorri â llaw (C2) yn bennaf, yn cynnwys gostyngiadau clir mewn cydrannau megis gorchudd graminoid, gorchudd sbwriel, gorchudd corlwyn ac uchder llystyfiant. Yn ogystal â hynny, ar y lleiniau lle roeddent yn cael eu canfod, gwelwyd gostyngiadau tebyg yn y gorchudd o *Cladium mariscus* a *Molinia caerulea.* Mae'r rhain i gyd yn rhagofynion arwyddocaol ar gyfer cyrraedd y cyflwr targed. Yn wir, mae tystiolaeth o'r lleiniau a barwyd ar gyfer 'Trin a Rheoli' yn awgrymu bod ymyrraeth gynnar ar ffurf torri â pheiriant (neu debyg) yn fwy na thebyg yn hanfodol er mwyn caniatáu i'r dwrn dreiddio i'r dywarchen.

Ar y rhan fwyaf o'r lleiniau, yn dilyn gostyngiadau cynnar cychwynnol, wedi hynny bu cynnydd blynyddol yn nifer o'r cydrannau hyn. Er, yn y rhan fwyaf o achosion, nad arweiniodd hynny at gynnydd blynyddol arwyddocaol na dychwelyd at lefelau gweithredu cyn rheoli dwys, mae'n gweithredu fel baromedr o effaith pori a theclyn empirig sydd â'r potensial i fod yn ddefnyddiol ar gyfer gwerthuso dwyster y pori sy'n angenrheidiol er mwyn cynnal amodau sy'n ffafriol i wella'r dywarchen.

Mae dangosyddion fel y gorchudd o rywogaethau dangos cadarnhaol, gan gynnwys bryoffytau, planhigion porfa a hesg main, yn dangos ymateb cymedrol i'r gwaith rheoli, gan adlewyrchu'r gorchudd cymharol cynhenid isel o'r rhywogaethau hyn mor gynnar yn y gwaith adfer, a hefyd amser annigonol ar gyfer recriwtio a thyfu.

1. INTRODUCTION

The Anglesey and Llŷn Fens LIFE + Nature Project was established in 2009 with the aim of restoring 751 hectares of fen within the Corsydd Môn/Anglesey Fens SAC and Corsydd Llŷn/Llŷn Fens SAC into favourable or recovering condition, through measures aimed at tackling the factors adversely affecting their condition, and by delivering more sympathetic management.

Prior to the *LIFE* Project, the Annex I habitats (alkaline and calcareous fen) were in an unfavourable condition due *inter alia* to the lack of effective management. This study was initiated to assess whether *LIFE* Project restoration and management actions were yielding improvements in habitat condition. The results provide an empirical evidence base on which to inform future management; they also provide information for other conservation practitioners on how best to manage lowland fens.

Management actions included controlled burning (C.8)[1], machine mowing using a bespoke PistenBully machine for cutting and removing biomass within calcareous fen and coarse graminoid-dominated fen communities (C.1), hand strimming and biomass removal by hand raking within alkaline fen (C.2), restoration of critical hydrological pathways and favourable hydrological regimes (C10 & C.11), excavation of peat cuttings and pools (C.13), installation of constructed treatment wetlands (C.14), and grazing (C.4).

This report describes the methodology employed for assessing the response of vegetation to applied management (LIFE Project action E.4.02). The description of the methodology includes the vegetation monitoring carried out by the *LIFE* Project Team and the associated Ph.D study of Nina Menichino at Bangor University. Results are presented here for those monitoring plots recorded by the LIFE team; results and data analysis for the PhD plots will be written up in a Ph.D thesis in 2015, although a preliminary account is appended in to this report (Annex 2).

[1] Codes relate to *LIFE* project actions.

2. METHODOLOGY

2.1. General approach

Two different methods of monitoring plot designs were used to look at how different vegetation communities responded to different cutting regimes on the four NNR sites included in the LIFE project (Cors Bodeilio [CB], Cors Erddreiniog [CE], Cors Goch [CGo] and Cors Geirch]CG]). The two methods employed were 'Before & After' plots and paired 'Treatment & Control' plots. The former approach utilised fixed points with vegetation data collected before applied management and then subsequently from exactly the same location. Locations were chosen using a combination of the detailed site action maps prepared as part of the original bid and also detailed vegetation maps from the CCW/NRW Lowland Peatland Survey of Wales: the latter were used to identify suitable areas of *Schoenus nigricans*-dominated alkaline fen (M13), *Cladium mariscus*-dominated calcareous fen (S2 and 'Cladio-molinietum'), *Juncus subnodulosus*-dominated fen meadow (M22) and degraded fen dominated by *Molinia caerulea* (M25). Blocks of vegetation needed to be at least 30 m x 30 m to fit either a 20 m x 20 m 'Before & After' plot or a pair of 10 m x 10 m 'Treatment & Control' plots, with an adequate buffer zone.

Initially in 2010, just before the start of the major machine cutting phase (action C.1), seven 20 m x 20 m 'Before & After' plots were set up to examine the effect of the large scale machine cutting on areas of derelict coarse graminoid-dominated vegetation; three in calcareous fen ('*Cladio-molinietum*') on Cors Bodeilio, two in fen meadow (M22) on Cors Erddreiniog, Bryn Mwcog (BM) and two in degraded fen (M25) on Cors Erddreiniog, Nant Isaf (NI). Details of plot names, monitoring dates and management treatments are given in Table 1.

The 20 m x 20 m plot size was chosen to cover a reasonable area of homogenous vegetation. Within each plot, five 2x2 m quadrats were sampled for all rooted species of vascular plants and bryophytes, giving both % cover ranges and Domin values, as defined in Table 2, for each species. Quadrats were randomly placed within each plot using random numbers generated on the website www.random.org, which was then divided by 10 to define the x and y co-ordinates that formed the south-west quadrat corners. This method had the effect of creating some quadrats that actually went outside the plot boundaries. Once the five quadrats had been created for a plot, the same quadrat locations were used for subsequent monitoring.

In 2011, a more experimental approach was taken, setting up a series of 19 paired 'Treatment and Control' plots looking at different cutting treatments: hand strimming on the more delicate *Schoenus nigricans*-dominated alkaline fen (M13), and machine cutting on coarser calcareous fen and *Juncus subnodulosus* fen meadow. Due to the limited availability of homogenous blocks of vegetation of sufficient size to accommodate a pair of 'Treatment and Control' plots, plot size was reduced to 10 m x 10 m, to allow a pair of plots to be side by side with a buffer zone between them. As with the 'Before & After' plots, five quadrats were randomly placed within each plot, but this time the plot was divided into 25 2x2 m squares (potential quadrats). Random numbers were used to generate x and y co-ordinates, then whichever square the co-ordinate landed in, was taken to be the quadrat. This eliminated the problem encountered with the 'Before & After' plots, where some quadrats actually went outside the plot boundaries. Three paired plots on Cors Geirch were monitored by the LIFE Project as detailed in Table 3, whilst the remaining 16 plots formed part of Nina Menichino's PhD at Bangor University, details are given in Annex 2.

There were two additional 'Before & After' plots on Cors Bodeilio and four paired 'Treatment & Control' plots on Cors Geirch, Cors Bodeilio and Cors Goch, that were monitoring was discontinued for a variety of reasons. Details of these are given in Table 4.

Table 1. Summary of 'Before & After' (B&A) plots: monitoring dates and treatments.

SSSI	Plot ref.	Fen habitat	Plot type	Dates monitored	Treatment	Treatment date
Cors Bodeilio	Cors Bodeilio Plot 1	Calcareous fen 'Cladio-Molinietum' b	B&A	28.9.10	Pony grazing (C4)	On-going
				16.9.11	Burning (C8), followed by cutting (C1)	Feb 2011
				3.7.12	Light cattle grazing (C4)	Summer 2012
				28.10.13	Pony grazing (C4)	On-going
Cors Bodeilio	Cors Bodeilio Plot 2	Calcareous fen 'Cladio-Molinietum' b	B&A	28.9.10	Pony grazing (C4)	On-going
				20.9.11	Burning (C8), followed by cutting	Feb 2011
				3.7.12	Light cattle grazing (C4)	Summer 2012
				29.10.13	Pony grazing	On-going
Cors Bodeilio	Cors Bodeilio Plot 3	Calcareous fen 'Cladio-Molinietum' a	B&A	14.10.10	Burning (C8)	February 2011
				12.08.12	Open to grazing (light cattle and pony)	From 2011
Cors Erddreiniog	Bryn Mwcog, Plot 1	M22a fen meadow	B&A	29.9.10	None	
				23.9.11	Machine mowing (C1)	October 2010
				5.9.12	No grazing	
				31.10.13	No grazing	
Cors Erddreiniog	Bryn Mwcog, Plot 2	M22c fen meadow	B&A	30.9.10	None	
				6.9.11	Machine mowing (C1)	October 2010
				7.9.12	No grazing	
Cors Erddreiniog	Nant Isaf, Plot 1	M25a fen meadow (*Cladium*)	B&A	1.10.10	None	
				29.9.11	Machine mowing (C1)	21.10.10
				13.9.12	Light cattle grazing (C4)	Summer 2012
				30.10.13	Pony grazing (C4)	Spring 2013 onwards
Cors Erddreiniog	Nant Isaf, Plot 2	M25 species-poor fen meadow (*Myrica*)	B&A	30.9.10	None	
				23.9.11	Machine mowing (C1)	21.10.10
				5.9.12	Light cattle grazing (C4)	Summer 2012
				30.10.13	Pony grazing (C4)	Spring 2013 onwards

Table 2. Definition of Domin values

% of ground surface covered	Qualifier	Domin score
91 – 100%	-	10
76 – 90%	-	9
51 – 75%	-	8
34 – 50%	-	7
26 – 33%	-	6
11 – 25%	-	5
4 – 10%	-	4
<4	Many individuals	3
<4	Several individuals	2
<4	Few individuals	1

Table 3. Summary of paired 'Treatment & Contol' plots monitored by the LIFE Project: monitoring dates and treatment.

SSSI	Plot ref.	Fen habitat	Plot type	Dates monitored	Treatment	Treatment date
Cors Geirch	Cors Ffynnon Wen (Bodtacho Ddu)* CG-BD-2-M13-T	Alkaline fen M13a	Treatment	4.8.11	None	-
				26.9.12	Hand-strimming (C2) & scrub removal (C7)	Feb 2012
					Light to medium cattle grazing (C2)	Summer 2012
				14.10.13	Light to medium cattle grazing (C2)	Summer 2013
Cors Geirch	Cors Ffynnon Wen (Bodtacho Ddu)* CG-BD-2-M13-C	Alkaline fen M13a	Control	4.8.11	None	-
				14.9.12 & 21.9.12	Light to medium cattle grazing (C2)	Summer 2012
				18.10.13	Light to medium cattle grazing (C2)	Summer 2013
Cors Geirch	CG-NNR-Cladio-T	Calcareous fen 'Cladio-Molinietum' a	Treatment	18.8.11	None	-
				None in 2012	Machine mowing (C1) then open to pony grazing (C2)	Feb 2012
				12.11.13	Open to pony grazing	On-going
Cors Geirch	CG-NNR-Cladio-C	Calcareous fen 'Cladio-Molinietum' a	Control	18.8.11	None	-
				None in 2012	Open to pony grazing (C2)	From Feb 2012
				12.11.13	Open to pony grazing	On-going
Cors Geirch	CG-NNR-M22-T	M22c fen meadow	Treatment	15.8.11	None	-
				None in 2012	Machine mowing (C1) then open to pony grazing (C2)	Feb 2012
				13.11.13	Open to pony grazing	On-going
Cors Geirch	CG-NNR-M22-C	M22c fen meadow	Control	15.8.11	None	-
				None in 2012	Open to pony grazing (C2)	From Feb 2012
				13.11.13	Open to pony grazing	On-going

* Cors Ffynnon Wen was initially called Bodtacho Ddu when the monitoring plots were set up.

Table 4. Summary of monitoring plots that were discontinued.

SSSI	Plot ref.	Fen habitat	Plot type	Dates monitored	Treatment	Treatment date	Reason for discontinuing the monitoring
Cors Bodeilio	Cors Bodeilio Plot 4	M22a fen meadow	14.9 m transect, 5 2x2 m quadrats, set up by P. Jones	23.09.2010 15.09.2011	Hand-strimming (C2) Open to grazing (light cattle and pony)	Jan 2011 2011	Pistenbully track through part of transect.
Cors Bodeilio	Cors Bodeilio Plot 5	Alkaline fen M9b	5 random 2x2 m quadrats set up by P. Jones	23.09.2010 20.09.2011	Hand-strimming (C2) Open to grazing (light cattle and pony)	Jan 2011 2011	Confusion over some of quadrat location.
Cors Bodeilio (Common)	CB-M13-1T	Alkaline fen M13a	Paired plot: Treatment	30.06.2011	N/A	N/A	Plot markers removed. Overlain with new PhD plot.
Cors Bodeilio (Common)	CB-M13-1C	Alkaline fen M13a	Paired plot: Control	30.06.2011	N/A	N/A	
Cors Geirch	Plas-yng-Neidio CG-PN-M13T	Alkaline fen M13b	Paired plot: Treatment	06.08.2011	Private ownership - cattle grazing with Charolais cross (under S15 MA), plus sheep (open to adjacent fields)	On-going	Good quality M13b, no strimming treatment undertaken. Control & treatment plots not similar enough at start of monitoring.
Cors Geirch	Plas-yng-Neidio CG-PN-M13C	Alkaline fen M13b	Paired plot: Control	06.08.2011	Private ownership - cattle grazing with Charolais cross (under S15 MA), plus sheep (open to adjacent fields)	On-going	
Cors Geirch	Tal y Sarn CG-TYS-M23-T	M23a fen meadow	Paired plot: Treatment	16.08.2011	Scrub clearance, grazing by ponies and cattle	2010	No cutting treatment undertaken in compartment and not a priority habitat.
Cors Geirch	Tal y Sarn CG-TYS-M23-C	M23a Fen meadow	Paired plot: Control	16.08.2011	Scrub clearance, grazing by ponies and cattle	2010	

Cors Goch	CGo-5-M22-T	M22 Fen meadow	Paired plot: Treatment	27.07.2011	Machine mowing (C1)	2012	Lack of resources to continue monitoring.
Cors Goch	CGo-5-M22-C	M22 Fen meadow	Paired plot: Control	27.07.2011	None	None	

2.2. Marking plots

Once a suitable block of homogenous vegetation was identified, the monitoring plot(s) (20 m x 20 m 'Before & After' plot or a pair of 10 m x 10 m 'Treatment & control' plots with a buffer zone between them) were measured out using tape measures and a compass, trying to make them as square as possible and in a north-south orientation, though this was a little challenging to achieve in stands of dense *Cladium mariscus* or tall *Phragmites australis*. Plot corners were marked out using 1.8 m canes with red and white tape flags for 'Before & After' and 'Control' plots, and black & yellow tape flags for 'Treatment' plots. A length of white plastic pipe was put around the base of each corner cane and a 10x10 cm square steel plate with a short spike was pushed into the ground to aid relocation by metal detector. The grid reference for each plot corner was recorded using a handheld GPS: Trimble GeoXT 2008 series with sub-1m accuracy. The data was subsequently post-processed (differential correction) to increase accuracy back in the office using data collected from the Holyhead RNLI base station and made available by Ordnance Survey via the National GPS Network website, and Pathfinder Office software (version 4.2).

After the plot was marked out and the orientation decided, the five randomly selected quadrats were measured out using tapes measures, and the corners marked with a 1.8 m canes. The quadrat corners were permanently marked with short lengths of white plastic pipe within the Ph.D study plots, but not the LIFE plots where quadrats were located by measurement from the plot corners on each monitoring occasion.

2.3. Treatments

The 'Before & After' plots were set up in 2010 and the quadrats sampled before the vegetation was cut by the PistenBully (C1). A member of the LIFE Team was present during cutting as the corner canes had to be removed prior to cutting by the machine and then replaced immediately afterwards.

With the paired 'Control & Treatment' plots, only the treatment plot was subject to vegetation cutting. As the alkaline fen plots were cut by hand strimmer and the litter raked away, this was carried out around the marker canes. For the plots within the calcareous fen and fen meadow that were cut using the PistenBully, as with the 'Before & After' plots, the canes marking the plot corners had to be removed prior to cutting and replaced immediately after cutting by either a member of the LIFE Team or the Ph.D student, who supervised the different treatment activities.

2.4. Vegetation recording

Most of the vegetation recording in the LIFE plots was carried out by CCW/NRW staff (including members of the *LIFE* team), with additional help from contractors (ADAS) in 2013. Some of the Ph.D plots were set up by the LIFE Project prior to a PhD student being recruited. Additional plots and subsequent monitoring was carried out by Nina Menichino and will be written up in her PhD thesis.

2.4.1. Equipment list

- Tape measures (2x50 m tapes & 2x30 m tapes)
- 6ft canes (16-20)
- 2x2 m quadrat or use 4x6ft canes
- Boreman pole & disc (140 cm high)
- 1 m fold out ruler/measuring stick
- Metal detector & spare batteries
- GPS (Ideally Trimble GeoXT 2008 series with sub-1m accuracy)
- Camera
- Compass
- Plot location sheet (back of this report)
- Blank recording forms (Figure 4). May need waterproof copies.
- Photos from previous year
- Weatherwriter & pen/pencil
- X20 hand lens
- Bryophyte packets
- Field identification guides

2.4.2. Vegetation recording on 20 x 20 m 'Before & After' plots

Key steps are listed in Table 5.

Table 5. Step-by-step guide to recording 'Before & After' vegetation plots.

Step	Procedure
1	Locate and measure out 20 m x 20m plot using two 50 m tape measures and 1.8 m canes for corners. GPS coordinates and metal detector may be needed to find steel plot markers if the corner canes have disappeared. Use location sheet to obtain the correct orientation for the plot.
2	The five quadrats are located by measuring the distances given in the Location Sheets, along the x and y axis from the south-west corner (∃, point 0,0 – see Figure 1) of the plot to the south-west corner of the quadrat, as shown in Figure 1. Note that part of some quadrats may fall outside the plot, for example coordinates 18.8, 17.3. It is best to mark out all the quadrats before recording the vegetation to prevent trampling on vegetation that may be in an adjacent quadrat. As the vegetation in many plots is tall, 1.8 m canes provide the best quadrat corner markers. Quadrat sides can be marked out using four additional canes by wrapping a tape measure around the corner canes, rather than trying to use a string quadrat.
3	Take a photo of each quadrat from the orientation indicated by the location sheet, usually north to south. Place the Boreman pole and measuring stick in front of the quadrat as an indication of vegetation height and scale of photo, as shown in Figure 2. Make a note of the photo number on the recording form and re-label photos immediately after fieldwork. Photos should be labelled with 'Site name-Plot number-Quadrat number-Year' e.g. 'CE-Plot 1-Q4-2011' or 'Nant Isaf-Plot 2-Q1-2013'.
4	Measure the Boreman disk height from the middle of the quadrat.
5	Use the Recording form in Figure 2 to record all vascular plant and bryophyte species present in the quadrat giving a % cover and DOMIN values given in Table 5. Special attention needs to be given to looking under vegetation and within tussocks for bryophytes. Recorded to species where possible; otherwise if unsure of field identification, collect samples in bryophyte packets for examination under a microscope.
6	Record percentage cover of litter and bare ground and make note of cover of standing water, water height, animal dung etc. if significant; and of any other factor which might affect the vegetation results such as poor weather.
7	Measure vegetation height range (min to max) of dwarf shrub, graminoids, forbs,

	bryophytes (non-*Sphagnum*), and *Sphagnum*.
8	Note if any markers are missing.

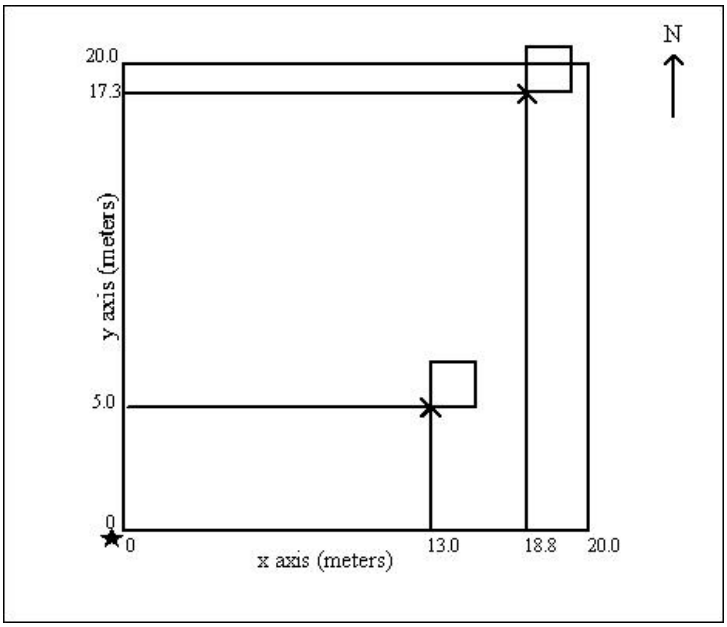


Figure 1.Example of measuring out quadrats within a 'Before & After' plot.

Figure 2. Example of quadrat photo with Boreman pole (140 cm) and measuring stick (75 cm) for scale.

2.4.3. Vegetation recording on 10 m x 10 m Paired 'Treatment & Control' plots

This method (Table 6) covers all paired plots, though there may be some minor differences in plot markers or recorded data for the plots covered by the PhD.

Table 6. Step-by-step guide to recording 'Treatment & Control' vegetation plots.

Step	Procedure
1	Locate and measure out pair of 10 m x 10m plot using two 50 m tape measures and 1.8 m canes for corners. GPS coordinates and metal detector may be needed to find steel plot markers if the corner canes have disappeared. Use location sheet to get the correct orientation for the plots.
2	The five quadrats are located by measuring the distances given in the Location Sheets, along the x and y axis from the south-west corner (∃, point 0,0) of the plot to the south-west corner of the quadrat, as shown in Figure 3. It is best to mark out both plots at the start to help with orientation and avoid walking on vegetation before sampling. All quadrats should be marked out within a plot before recording the vegetation to prevent trampling on vegetation that may be in an adjacent quadrat. As the vegetation in many plots is tall, 6ft canes provide the best quadrat corner markers. Quadrat sides can be marked out using four additional canes by wrapping a tape measure around the corner canes, rather than trying to use a string quadrat. Care needs to be taken to identify 'Treatment' & 'Control' plots before starting to record the vegetation.
3	Take a photo of each quadrat from the orientation indicated by the location sheet, usually north to south. Place the Boreman pole and measuring stick in front of the quadrat as an indication of vegetation height and scale of photo, as shown in Figure 2. Make a note of the photo number on the recording form and re-label photos immediately after fieldwork. Photos should be labelled with 'Site code-habitat-Control (C) or Treatment (T)-Quadrat-Year' e.g. 'CG-BD-M13-T-1 -2013' (Cors Geirch, Bodtacho Ddu-M13-Treatment-Q1-2013).
4	Measure the Boreman disk height from the middle of the quadrat.
5	Use the Recording form in Figure 4 to record all vascular plant and bryophyte species present in the quadrat giving a % cover and DOMIN values given in Table 5. Special attention needs to be given to looking under vegetation and within tussocks for bryophytes. Recorded to species where possible; otherwise if unsure of field identification, collect samples in bryophyte packets for examination under a microscope.
6	Record percentage cover of litter and bare ground and make note of cover of standing water, water height, animal dung etc. if significant; and of any other factor which might affect the vegetation results such as poor weather.
7	Measure vegetation height range (min to max) of dwarf shrub, graminoids, forbs, bryophytes (non-*Sphagnum*), and *Sphagnum*.
8	Note if any markers are missing.

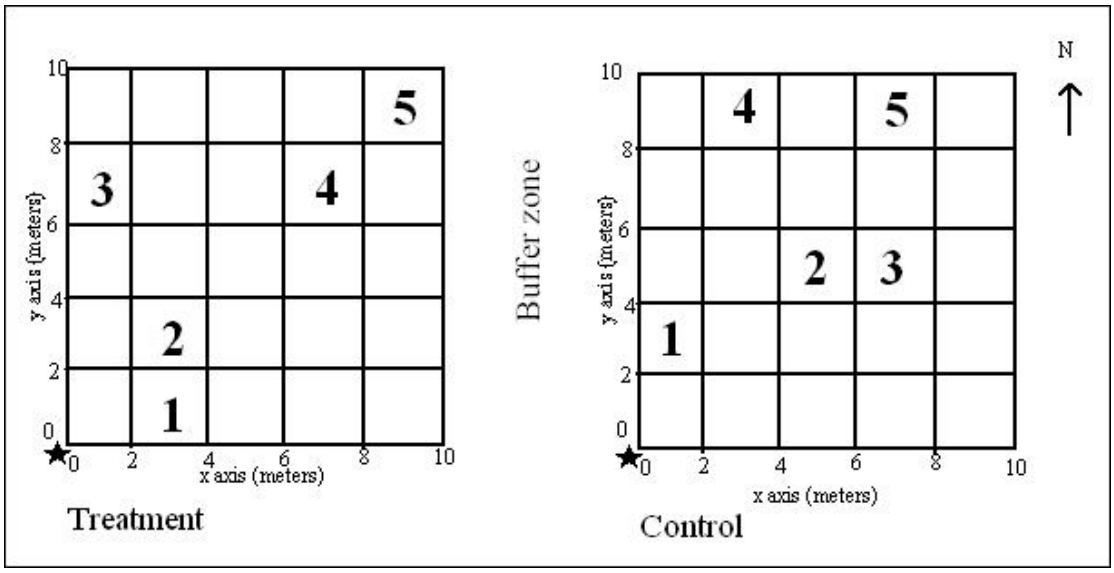


Figure 3. .Example of measuring out quadrats within a pair of 'Control & Treatment' plots.

SITE NAME:			DATE:			% = Plot No/Quadrat No ;					
NVC COMMUNITY:			SURVEYOR:			D = Plot No/Quadrat No ;			PHOTO:		

%	D	TREES		%	D	Carex	limosa	%	D	Galium	uliginosum	%	D	Calliergon	giganteum
		Alnus	glutinosa (c)				nigra			Gymnadenia	conop				sarment
		Betula	pendula (c)				panicea			Hydrocotyle	vulgaris				stramin
			pubescens (c)				pulicaris			Hypericum	elodes			Callierg'la	cuspidata
		Fraxinus	excelsior (c)				rostrata				pulchrum			Camp'delphus	elodes*
		Quercus	petraea (c)				virid ssp brach				tetrapt			Campylium	stell v proten*
			robur (c)				virid ssp oedo			Iris	pseudacor				stell v stell
		Salix	caprea (c)			Cladium	mariscus			Lathyrus	pratensis			Campylopus	atrov
			cinerea (c)			Dactylorhiza	fuchsii			Lemna	minor				flexuos*
			viminalis (c)				incarn			Linum	cathartic				introfl
		Sorbus	aucupar (c)				macul			Lotus	pedunculat				pyrifor*
%	D	SAPLINGS & SHRUBS					purpur			Lychnis	flos-cucul			Climacium	dendroid
		Alnus	glutinosa (s)				traunst			Lycopus	europae			Cratoneuron	filicinum
		Betula	pendula (s)			Danthonia	decumb			Lysimachia	vulgaris			Ctenidium	molluscum
			pubescens (s)			Descham	cesp cesp			Lythrum	salicar			Dicranella	heterom
		Fraxinus	excelsior (s)				flexuosa			Mentha	aquatic				palustris
		Quercus	petraea (s)			Eleocharis	multicaul			Menyanthes	trifoliat			Dicranum	bonjeani*
			robur (s)				palustris			Myosotis	laxa cesp				scoparium
		Salix	aurita				quinquef				scorpioid			Drepanocl	cossonii
			caprea (s)				uniglumis				secunda				revolv ss
			cinerea (s)			Eleogiton	fluitans			Oenanthe	lachenal			Eurhynchium	prael
			repens			Eriophorum	angustif			Parnassia	palustris			Fissidens	adianth
			viminalis (s)				gracile			Pedicularis	palustris			Hylocomium	splend
		Sorbus	aucupar (s)				latifolium			Pinguicula	vulgaris			Hypnum	cupressif ss
%	D	TREE & SHRUB SEED'Gs				Festuca	ovina			Plantago	lanceolat				jutlandicum
		Alnus	glutinosa (sd)				pratensis			Polygala	serpyllif			Leucobryum	glaucum
		Betula	pendula (sd)				rubra			Potamogeton	color			Palustr	comm v comm
			pubesc (sd)			Glyceria	declinat				natan				comm v falcat
		Fraxinus	excelsior (sd)				fluitans				polyg			Philonotis	calcarea
		Quercus	petraea (sd)				maxima			Potentilla	erecta				fontana
			robur (sd)				notata				palustris			Plagiomnium	elatum*
		Salix	aurita (sd)			Holcus	lanatus			Prunella	vulgaris				ellipt*
			caprea (sd)			Isolepis	setacea			Ranunculus	acris				rostr*
			cinerea (sd)			Juncus	acutiflor				flamm				undul
			repens (sd)				articulatus				heder			Plag'thecium	dentic*
			viminalis (sd)				bulbosus				lingua				latebr*
		Sorbus	aucupar (sd)				conglomer				repens				undul
%	D	DWARF SHRUBS					effusus			Rhinanthus	minor			Pleurozium	schreber
		Calluna	vulgaris				inflexus			Rubus	fruti agg.			Polytrichum	comm
		Erica	tetralix				subnodulos			Rumex	acetosa			Rhizomnium	pseud*
		Genista	anglica			Luzula	campestr				hydrolap				punct
		Myrica	gale				multiflora			Sagina	nodosa			Rhytidiadelph	squar
		Ulex	europae			Molinia	caerulea			Samolus	valerand			Scleropodium	purum
			gallii			Narthecium	ossifrag			Scutellaria	galericul			Scorpidium	scorpid
%	D	FERNS				Phragmites	australis				minor			Sphagnum	contort
		Athyrium	filix-fem			Poa	humilis			Senecio	aquatic				fimbriat
		Dryopteris	carthus			Schoenus	nigrican				jacobea				palustre*
			dilatata			Typha	latifolia			Serratula	tinctor				subniten
			filix-mas	%	D	HERBS				Solanum	dulcamara			Thuidium	delicatul*
		Equisetum	arvens			Achillea	ptarmic			Sparganium	erectum				tamarisc
			fluviatile			Alisma	plant-aqu			Stachys	palustris			Tomentypnum	nitens*
			palustre			Anagallis	tenella			Stellaria	alsine			Warnstorfia	exann
			pratense			Angelica	sylvestr			Succisa	pratensis	%	D	LIVERWORTS	
			sylvatic			Apium	nodiflorum			Taraxacum	offic agg.			Aneura	pinguis
			telmateia			Baldellia	ranuncul			Trifolium	pratense			Calypogeia	fissa
		Selaginella	selagin			Berula	erecta				repens				muell
%	D	GRAMINOIDS				Caltha	palustris			Triglochin	palustre			Cephalozia	bicusp
		Agrostis	canina			Calystegia	sepium			Urtica	dioica				conniv*
			capillaris			Cardamine	flexuos			Utricularia	austrlais*			Cephaloziella	hamp*
			stolonifera				pratensis				interm*				sp.*
		Alopecurus	genicul			Centaurea	nigra				minor			Chiloscyphus	palles
		Anthoxanth	odorat			Cerastium	fontanum				vulgaris*			Lophocolea	biden sl
		Arrhenather	elatius			Cirsium	arvense			Valeriana	dioica			Lophozia	ventricosa
		Briza	media				palustre				officinalis			Marchantia	poly poly
		Carex	acuta			Drosera	rotundifolia			Veronica	anag-aqu			Pellia	endiviifolia
			acutiformis			Epilobium	hirsutum				beccabun				epiphylla
			curta				obscurum				chamaed				neesiana
			diandra				palustre				scutellat			Preissia	quadrata*
			dioica				parviflor			Vicia	cracca			Riccardia	chamed*
			disticha			Epipactis	palustris			Viola	palustris				latifrons*
			echinata			Eupatorium	cannab	%	D	MOSSES					multifida*
			elata			Euphrasia	sp.			Aulacomnium	palus			Trichocolea	toment
			flacca			Filipendula	ulmaria			Brachythecium	rivul	%	D	STONEWORTS	
			hirta			Galeopsis	tetrahit				rutab			Chara	sp
			hostiana			Galium	aparine			Bryum	pseudotriq sl			algae	
			lasiocarp				palustre			Calliergon	cordifolium			Water cover	
														Hay	

ADDITIONAL SPECIES

VEGETATION STRUCTURE

ELEMENT	%	D	HEIGHT (CM) %	HEIGHT (CM) D
DWARF SHRUB				
GRAMINOID				
FORB				
BRYOPHYTE (non-spahgnum)				
SPHAGNUM				
LITTER (%)				
BARE SUBSTRATE (%)				

hoof print

Figure 4. Recording form.

2.5. Data analysis

2.5.1. Variables

The analysed variables for comparison over the years are listed below in four groups. The species selected were chosen as they embody Common Standards Monitoring Performance Indicators (JNCC, 2004).

Positive Indicators

1. **Bryophytes** (Brown & green mosses) including *Calliergonella cuspidata*, *Calliergon* spp., *Palustriella commutata* [*Cratoneuron commutatum*], *Cratoneuron filicinum*, *Scorpidium scorpioides*, *Campylium stellatum* and *Drepanocladus* spp.
2. **Positive Indicator Species**: *Angelica sylvestris*, *Cardamine pratensis Eupatorium cannabinum*, *Galium uliginosum, Mentha* spp., *Menyanthes trifoliata*, *Pedicularis palustris*, *Potentilla palustris, Schoenus nigricans*, *Serratula tinctoria* and *Succisa pratensis*.
3. **Low / slender sedges**: *Carex diandra*, *C. lasiocarpa*, *C. nigra*, *C. rostrata*, *E. gracile*, *E. latifolium*, *C. dioica*, *C. flacca*, *C. hostiana*, *C. limosa*, *C. pulicaris*, *C. panicea*, *C. viridula*, ssp. *brachyrhyncha* & ssp. *oedocarpa*, *Eleocharis multicaulis*, *E. quinqueflora* and *Eriophorum angustifolium*.

Negative Indicators – cover of the following taxa:

- *Phragmites australis*
- *Molinia caerulea*
- *Cladium mariscus*

Vegetation Structure

1) Litter cover
2) Vegetation height (the overall vegetation height is given by the maximum Boreman disk height (cm)).
3) Bare substrate cover
4) Graminoid cover
5) Herb cover
6) Dwarf shrub cover (*Calluna vulgaris, Erica tetralix, Genista anglica, Myrica gale, Ulex europaeus* and *Ulex gallii*).

2.5.2. Species Diversity

1. Species Richness
2. Shannon-based Index

Analysis of the number of species in a plot over time was carried out in order to provide a simple measure of species richness, and how this varied over time. However, the relative abundance of species is also a key element in diversity calculations, but in this survey due to the nature of the data, it was not possible to know the proportion of individuals of a species.

Consequently, a diversity index based on the Shannon-Wiener index was also calculated, as shown in Tables x & y. This utilises percentage cover data (as opposed to numbers of individuals) to provide an estimate for the proportion of each species in a plot. Hence, this index provides an indication of the variation in species diversity, in terms of species evenness as well as richness.

2.5.3. Statistical calculations

'Before & After' plots: For each plot on each site the mean values and variances were calculated for the 13 variables for each of the 4 years monitored. The variation with time for the different variables is shown, using graphs and tables that include percentage changes from year to year. Significant results between years are highlighted.

Paired 'Treatment & Control' plots: For each plot on each site the mean values and variances were calculated for the 13 variables for each of the 3 years monitored. In addition, analysis between Treatment and Control was carried out for 2013. Again, graphs and tables showing any changes with time are presented, and significant findings are highlighted.

Initial investigative analysis revealed that the data frequently did not meet the criteria for a parametric test. Principally, data appeared skewed. However, this was obscured by the small sample size which rendered it problematic to ascertain frequency distribution. Therefore, precautionary, distribution free, non-parametric statistical techniques (Mann-Whitney *U*-test) were employed to test for significant differences between population *medians*.

3. RESULTS

Results are presented for individual plots. Highlighted text indicates the vegetation attributes defined under section 2.5.1.

3.1. 'Before & After' Plots, Cors Bodeilio calcareous fen (*Cladio-Molinietum*).

Cors Bodeilio Plot 1, calcareous fen *(2010 onwards, light grazing [ponies]; 2011 burnt and mown [C1]; 2012 light grazing by cattle)*

Bryophyte cover increased following restoration management (Figure 5). After an increase between 2010 and 2011 following the onset of burning and mowing, positive indicator species then decreased between 2011 and 2012 but show an overall site increase between 2010 and 2013.

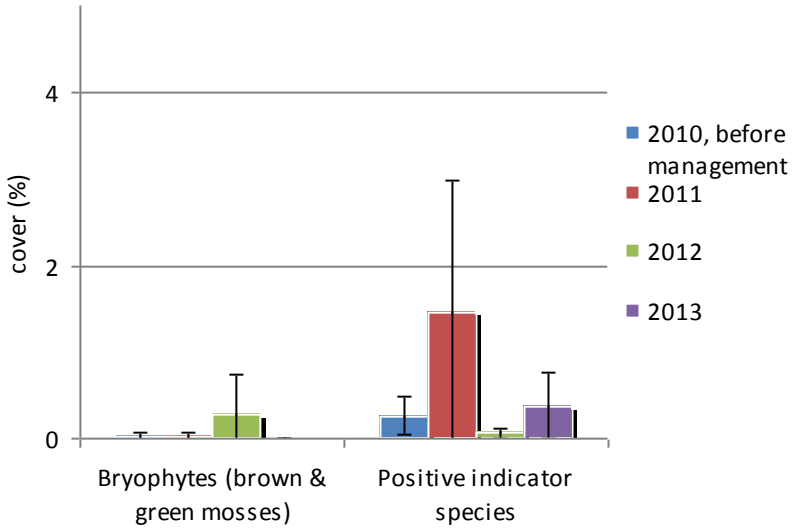


Figure 5. Cover of bryophytes and positive indicator species, Cors Bodeilio 'Before & After' Plot 1. Error bars are 1 Standard Deviation.

Low and slender sedges increased between 2010 and 2012 (Figure 6). There was an overall reduction in *Cladium mariscus* cover between 2010 and 2013. However, this *may be* increasing year-on-year from a low in 2011. Dwarf shrub cover and **Graminoid** covers have both decreased between 2010 and 2013, but Graminoid cover has increased from a low immediately after restoration management in 2011. Forb cover increased between 2010 and 2011 but then decreased to 2013. There was however no significant change between 2010 and 2013. Litter cover has decreased sharply between 2010 and 2013, albeit with an increase between 2012 and 2013 due to insufficient grazing. Bare substrate cover decreased between 2010 and 2011. Vegetation height has decreased between 2010 and 2013 (Figure 17). However, it has increased from a low in 2011. Species richness (Figure 18) and species diversity (Figure 19) generally show only modest changes between 2010 and 2013; both inter-year fluctuations. The cover of *Molinia caerulea*.declined slightly.

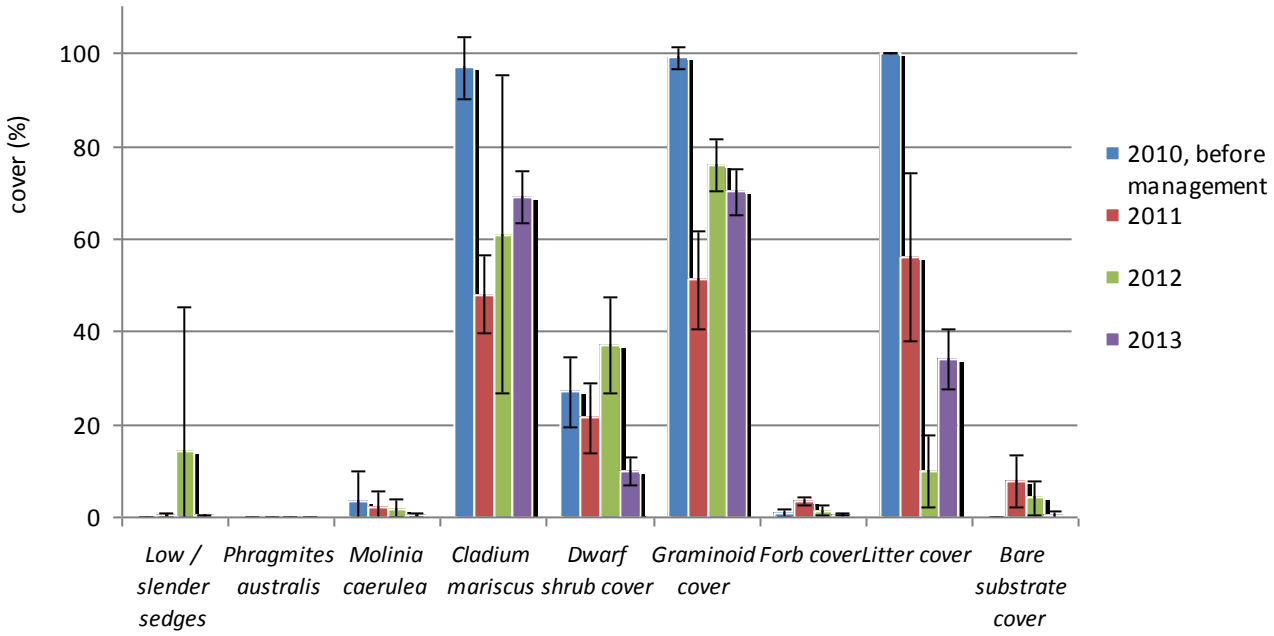


Figure 6. Changes in key vegetation attributes between 2010 and 2013; Cors Bodeilio 'Before & After' Plot 1. Error bars are 1 Standard Deviation.

Table 7. Direction and significance of changes (*P<0.05*) in key vegetation attributes between 2010 and 2013; Cors Bodeilio 'Before & After' Plot 1.

Variable	Years	Change (+/-)
Bryophytes	2012 V's 2013	-
Positive indicator species	2011 V's 2012	-
Low / slender sedges	2010 V's 2013	+
Phragmites australis	N/A	N/A
Molinia caerulea	N/A	N/A
Cladium mariscus	2010 V's 2011 2010 V's 2013	- -
Dwarf shrub cover	2011 V's 2012 2012 V's 2013 2010 V's 2013	+ - -
Graminoid cover	2010 V's 2011 2011 V's 2012 2010 V's 2013	- + -
Forb cover	2010 V's 2011 2011 V's 2012	+ -
Litter cover	2010 V's 2011 2011 V's 2012 2012 V's 2013 2010 V's 2013	- - + -
Bare substrate cover	2010 V's 2011	+
Vegetation height	2010 V's 2011 2011 V's 2012 2010 V's 2013	- + -
Species richness	2010 V's 2011 2012 V's 2013	+ -
Species diversity	2012 V's 2013	-

Cors Bodeilio Plot 2, calcareous fen *(2010 onwards, light grazing [ponies]; 2011 burnt and mown [C1]; 2012 light grazing by cattle).*

Molinia caerulea has shown a sharp initial and then sustained decline in cover (Figure 7). Dwarf shrub cover (in this case mostly tall *Myrica gale*) has decreased between 2010 and 2013 and, with the exception of 2011 and 2012, has shown inter-year decreases. Graminoid cover has decreased, with a slight overall decrease in *Cladium* cover between 2010 and 2013. Litter cover showed a very sharp initial decrease but increased between 2012 and 2013. There was a decrease in Bare substrate cover between 2011 and 2012, However, no change was recorded between 2010 and 2013. Following an initial significant decrease between 2010 and 2011, Vegetation height (Figure 17) remains unchanged between 2010 and 2013, though it declined sharply after restoration management. Species richness has remained unchanged until a decrease was recorded between 2012 and 2013. This resulted in a corresponding decrease between 2010 and 2013.

Bryophyte cover increased slightly over the recording period (Figure 8). The cover of Positive indicator species has declined: low and slender sedge and forb cover were relatively stable.

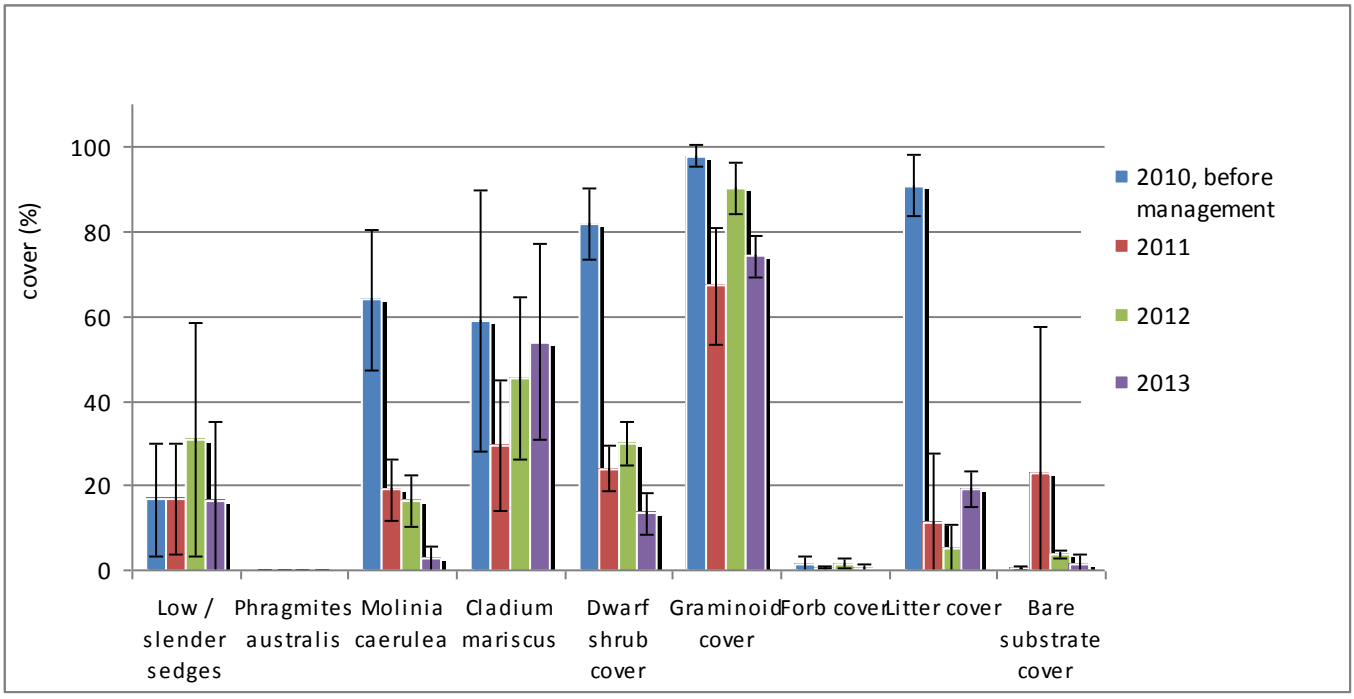


Figure 7. Changes in key vegetation attributes between 2010 and 2013; Cors Bodeilio 'Before & After' Plot 2. Error bars are 1 Standard Deviation.

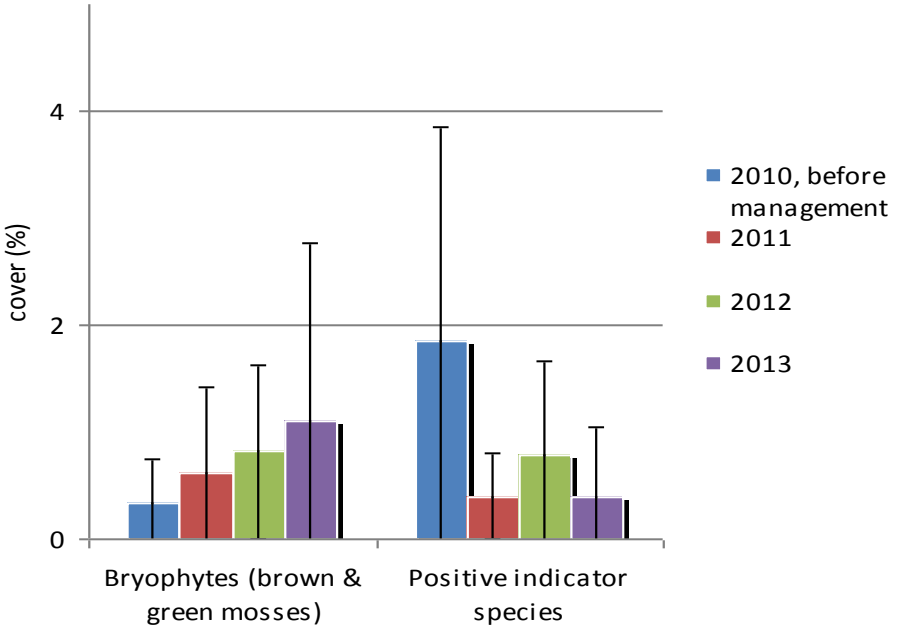


Figure 8. Cover of bryophytes and positive indicator species, Cors Bodeilio 'Before & After' Plot 2. Error bars are 1 Standard Deviation.

Table 8. Direction and significance (*P<0.05*) of changes in key vegetation attributes between 2010 and 2013; Cors Bodeilio 'Before & After' Plot 2.

Variable	Years	Change (+/-)
Bryophytes	N/A	N/A
Positive indicator species	N/A	N/A
Low / slender sedges	N/A	N/A
Phragmites australis	N/A	N/A
Molinia caerulea	2010 V's 2011 2012 V's 2013 2010 V's 2013	- - -
Cladium mariscus	N/A	N/A
Dwarf shrub cover	2010 V's 2011 2012 V's 2013 2010 V's 2013	- - -
Graminoid cover	2010 V's 2011 2011 V's 2012 2012 V's 2013 2010 V's 2013	- + - -
Forb cover	N/A	N/A
Litter cover	2010 V's 2011 2012 V's 2013 2010 V's 2013	- + -
Bare substrate cover	2010 V's 2011	+
Vegetation height	2010 V's 2011	-
Species richness	2012 V's 2013 2010 V's 2013	- -
Species diversity	N/A	N/A

Obvious changes have occurred in both Cors Bodeilio calcareous fen plots 1 and 2 over the monitoring period which covers a period of intensive management in the form of an initial burn followed by cutting in September 2011. This was followed by light grazing. This has resulted in clear reductions in litter, graminoids and dwarf shrub cover. On Plot

2, this was matched by a reduction in *Molinia caerulea*, although this response is far less evident in Plot 1 with its very low initial *Molinia* cover. *Cladium mariscus* was also reduced following burning on Plot 1. This was maintained throughout the monitoring period. However, although only statistically significant in a single inter-year period, there has been an upward trend in cover since that period, which is a situation that is also echoed in Plot 2. Not surprisingly, vegetation height has also shown a similar response, with an initial large reduction, followed by recovery. This has been to such an extent that on Plot 2 by 2013, vegetation height had returned to 2010 levels.

The recorded vegetation responses collectively contribute to a trend of improving condition. Burning and mowing succeeded in opening up the canopy, reducing the dominance of competitive species and litter, and permitting colonisation by desirable species. However, both litter cover and *Cladium* cover increased in the last year of monitoring, and for both plots the response of low and slender sedges and positive indicator species were somewhat equivocal; these observations suggest that subsequent grazing was a little too light (though see below). With regard to positive indicator species, the significance of the availability of source parent material within the immediate vicinity from which re-colonisation can take place has been discussed previously (ADAS 2013). The low cover values recorded for these species within the plots indicates that this is a limiting factor. Indeed, it may also be the case that a significant proportion of recorded positive indicator species, may not have been of reproductive age.

Observation in 2015 of the stand in which plots 1 and 2 are located has confirmed that overall vegetation condition is much improved relative to 2010. The patches of open M13 are now more prominent and low sedge elements (including *Carex pulicaris* and *C. hostiana*) are more widespread, even in the Cladio-Molinietum. It is suggested that grazing levels could be increased by at least 25% in this stand.

Cors Bodeilio plot 3 was only subject to two monitoring rounds and is close to one of the Ph.D study plots; for these reasons no further analysis has been undertaken.

3.2. ‘Before & After’ Plots, Bryn Mwcog (Cors Erddreiniog), M22 fen meadow,

These plots are located in an area with extant calcareous fen but also with areas of M22 which could be managed to allow calcareous fen expansion – see Technical Report No. 3). Plot 1 is located in M22a vegetation, plot 2 in M22c.

Bryn Mwcog Plot 1, calcareous fen *(2010 no management, 2011 mown [C1]; 2012 onwards no management, though occasional light grazing by ponies may have occurred.)*

Bryophyte cover increased between 2010 and 2013 (Figure 9, Table 9). Dwarf shrub cover (in this case *Myrica gale*) recovered between 2012 and 2013 after a sharp decline caused by mowing. Both graminoid cover and litter cover decreased between 2010 and 2013, though graminoid cover increased from the 2011 low point. Despite inter-year fluctuations species diversity remained unchanged between 2010 and 2013 (Figure 19).

There have been no significant changes in the cover of Positive indicator species, Low and slender sedges (Figure 10), *Phragmites australis*, *Molinia caerulea*, Forb cover and Bare substrate cover (Figure 9). However, *Molinia* and *Phragmites* cover in 2013 remained substantially less than the 2010 (pre-management) cover, despite lack of targeted follow-up grazing management. Vegetation height (Figure 17) was above Boreman disc height in all years).

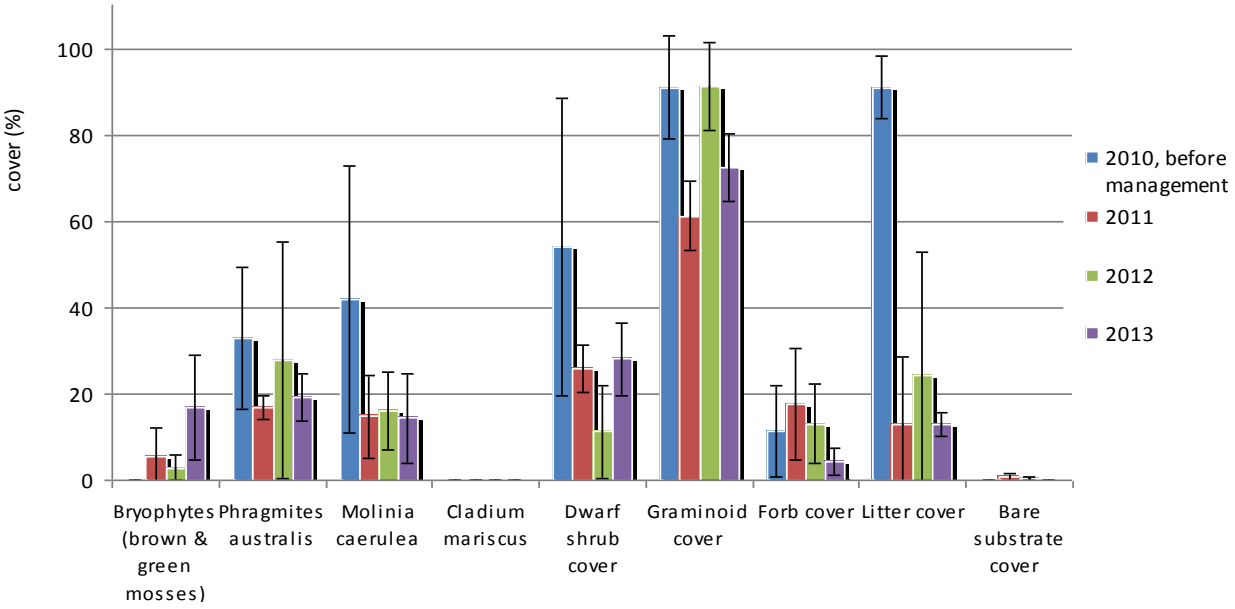


Figure 9. Changes in key vegetation attributes between 2010 and 2013; Bryn Mwcog (Cors Erddreiniog) 'Before & After' Plot 1. Error bars are 1 Standard Deviation.

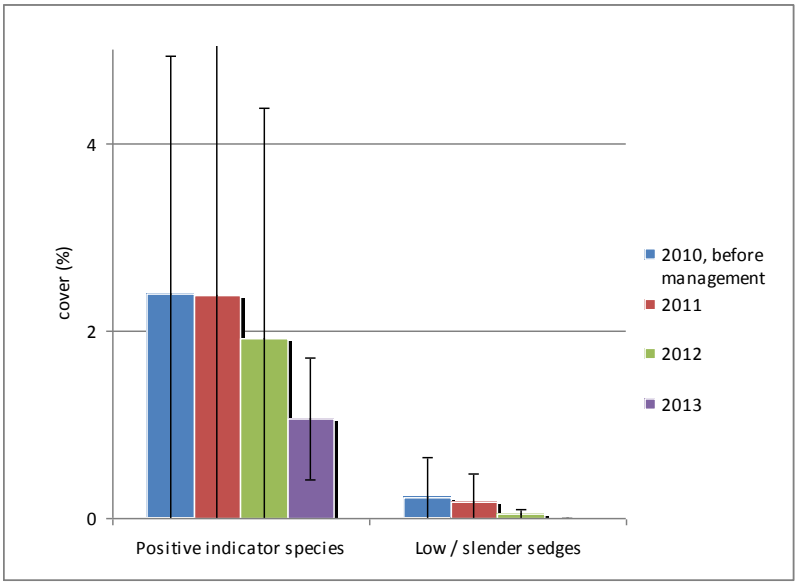


Figure 10. Changes in the cover of Positive Indicator Species and Low/slender Sedges between 2010 and 2013; Bryn Mwcog (Cors Erddreiniog) 'Before & After' Plot 1. Error bars are 1 Standard Deviation.

Table 9. Direction and significance (*P<0.05*) of changes in key vegetation attributes between 2010 and 2013; Bryn Mwcog 'Before & After' Plot 1.

Variable	Years	Change (+/-)
Bryophytes	2010 V's 2011 2012 V's 2013 2010 V's 2013	- + +
Positive indicator species	N/A	N/A
Low / slender sedges	N/A	N/A
Phragmites australis	N/A	N/A
Molinia caerulea	N/A	N/A
Cladium mariscus	N/A	N/A
Dwarf shrub cover	2012 V's 2013	+
Graminoid cover	2010 V's 2011 2011 V's 2012 2012 V's 2013 2010 V's 2013	- + - -
Forb cover	N/A	N/A
Litter cover	2010 V's 2011 2010 V's 2013	- -
Bare substrate cover	N/A	N/A
Vegetation height	N/A	N/A
Species richness	N/A	N/A
Species diversity	2010 V's 2011 2011 V's 2012	+ -

Bryn Mwcog Plot 2, calcareous fen *(2010 no management, 2011 mown [C1]; 2012 onwards no management, though occasional light grazing by ponies may have occurred.).*

Bryophytes increased between 2010 and 2012. Dwarf shrub cover shows a decreasing trend through all years (Figure 11, Table 10). This is statistically significant between 2011 and 2012, and 2010 and 2012. Graminoid cover decreased between 2010 and 2011 and also between 2010 and 2012. Litter cover has decreased through all years, with a very sharp decrease after the management year (2010). Bare substrate cover increased between 2010 and 2011 and overall between 2010 and 2012, though the overall extent of bare substrate remains low. Vegetation height decreased between 2010 and 2011, but then increased between 2011 and 2012; taking all years into consideration, there was an increase between 2010 and 2012 (Figure 17). Species richness increased between 2010 and 2011 but has shown no increase between 2010 and 2012. Species diversity has increased between 2011 and 2012 and also overall between 2010 and 2012. The cover of positive indicator species increased following management (Figure 12): the cover of *Phragmites* and *Molinia* decreased (Figure 11).

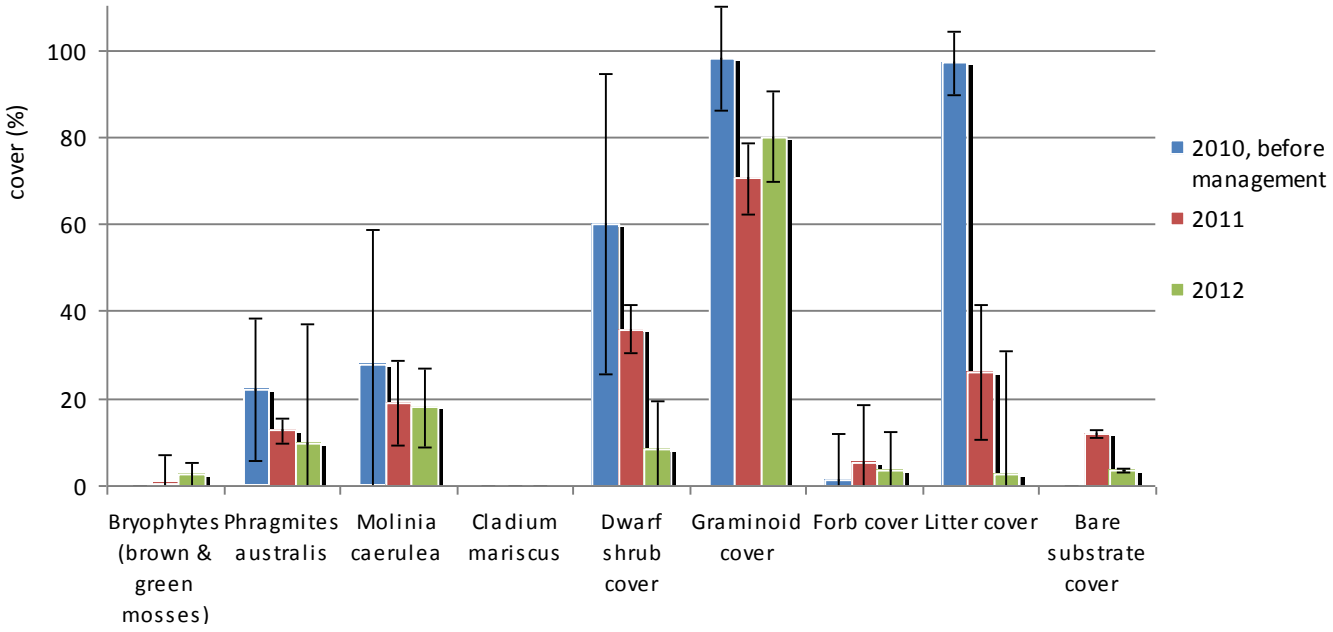


Figure 11. Changes in key vegetation attributes between 2010 and 2013; Bryn Mwcog (Cors Erddreiniog) 'Before & After' Plot 1. Error bars are 1 Standard Deviation. No data were recorded in 2013.

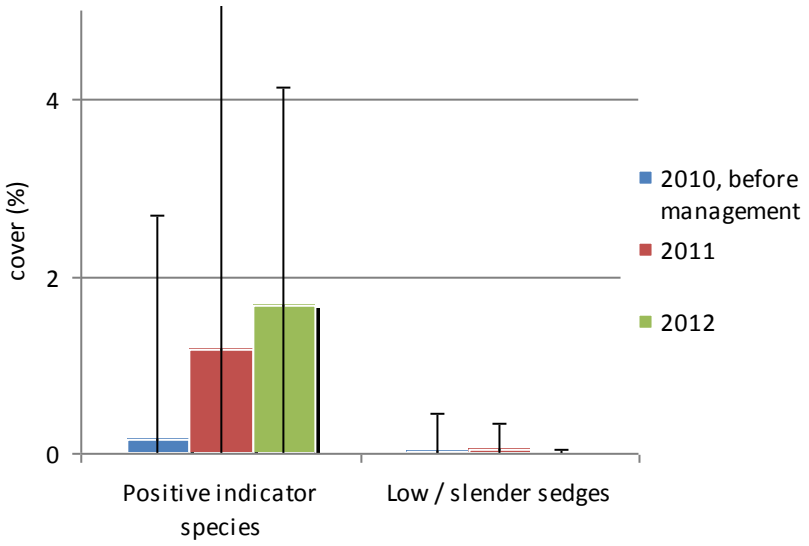


Figure 12. Changes in the cover of Positive Indicator Species and Low/slender Sedges between 2010 and 2013; Bryn Mwcog (Cors Erddreiniog) 'Before & After' Plot 2. Error bars are 1 Standard Deviation.

Table 10. Direction and significance (*P<0.05*) of changes in key vegetation attributes between 2010 and 2013; Bryn Mwcog 'Before & After' Plot 2.

Variable	Years	Change (+/-)
Bryophytes	2010 V's 2012	+
Positive indicator species	N/A	N/A
Low / slender sedges	N/A	N/A
Phragmites australis	N/A	N/A
Molinia caerulea	N/A	N/A
Cladium mariscus	N/A	N/A
Dwarf shrub cover	2011 V's 2012 2010 V's 2012	- -
Graminoid cover	2010 V's 2011 2010 V's 2012	- -
Forb cover	N/A	N/A
Litter cover	2010 V's 2011 2011 V's 2012 2010 V's 2012	- - -
Bare substrate cover	2010 V's 2011 2010 V's 2012	+ +
Vegetation height	2010 V's 2011 2011 V's 2012 2010 V's 2012	- + +
Species richness	2010 V's 2011	+
Species diversity	2011 V's 2012 2010 V's 2012	+ +

'Before & After' Bryn Mwcog Plots 1 and 2 *Juncus subnodulosus* fen meadow (M22a & M22c)

On both of these plots machine mowing was carried out in October 2010; no subsequent management was been carried out. This has resulted in significant early reductions in Litter cover and Graminoid cover on both plots. Interestingly, even in the absence of follow-up grazing and subsequent inter-year graminoid recovery, this has not thus far, resulted in subsequent litter build up. Unsurprisingly, Dwarf shrub cover followed a similar response profile on both plots with an initial reduction followed by partial recovery. Lack of follow-up grazing has had a pronounced effect on vegetation height. This was above the Boreman disc height throughout the study period on Plot 1, and had recovered on Plot 2 to a similar level by 2012. It is noteworthy that in comparison to Cors Bodeilio Plots 1 and 2, there has been no significant recorded change in *Molinia caerulea* cover on either plot, though cover has clearly declined. This tends to support the supposition that it was able to recover rapidly from the early cut due to lack of follow-up grazing on the Cors Erddreiniog, Bryn Mwcog plots. Similarly, *Phragmites australis* cover has declined on both plots, but still remains as a significant biomass component in the absence of grazing following cutting.

Early vegetation responses are conducive to achieving target condition states. However, the significant remaining cover of *Molinia caerulea*, and *Phragmites australis*, (and *Juncus subnodulosus,* which is not individually reported here) may be a factor limiting increases in other variables such as the cover of low and slender sedges and Positive Indicator species; as discussed above, availability of parent material is also likely to be a limiting element.

3.3. ‘Before & After’ Plots, Nant Isaf (Cors Erddreiniog), M25

These plots are located in an area with extant calcareous fen but also with extensive areas of *M25* Molinia dominated mire which could be managed to allow calcareous fen expansion – see Technical Report No. 3). Plot 1 is located in M25a vegetation with *Cladium*, plot 2 in M25 species-poor.

‘Before & After’ Nant Isaf Plot 1, M25a with *Cladium* *(2010 no management, 2011 mown [C1]; 2012 cattle grazing, 2013 pony grazing).*

There was a significant reduction in the cover of *Molinia caerulea* between 2010 and 2011, but with increasing cover (though not significant) since; overall, there has been a decrease between 2010 and 2013 (Figure 13). Dwarf shrub cover and graminoid cover declined markedly between 2010 and 2013, though since the low point in 2011 there has been an increasing trend (significant between 2011 and 2012); both cover elements reduced overall between 2010 and 2013. Forbs have yielded a variable inter-year response with an increase between 2011 and 2012, followed by a decrease between 2012 and 2013. However, there has been no overall change over the period 2010 and 2013. Litter cover decreased significantly between 2011 and 2012 and overall between 2010 and 2013. Bare substrate cover has recorded a variable response with an increase between 2011 and 2012, followed by a corresponding magnitude decrease between 2012 and 2013. However, there has been an overall recorded increase between 2010 and 2013. There has been a decrease overall in vegetation height (Figure 17) between 2010 and 2013, though this has been increasing (not significant) since the mowing in 2011. Both species richness and species diversity increased between 2011 and 2012, but there was no significant overall change between 2010 and 2013 (Figure 18, 19). There were no significant changes in the cover of bryophytes, positive indicator species, low and slender sedges, *Phragmites australis* and *Cladium mariscus*.

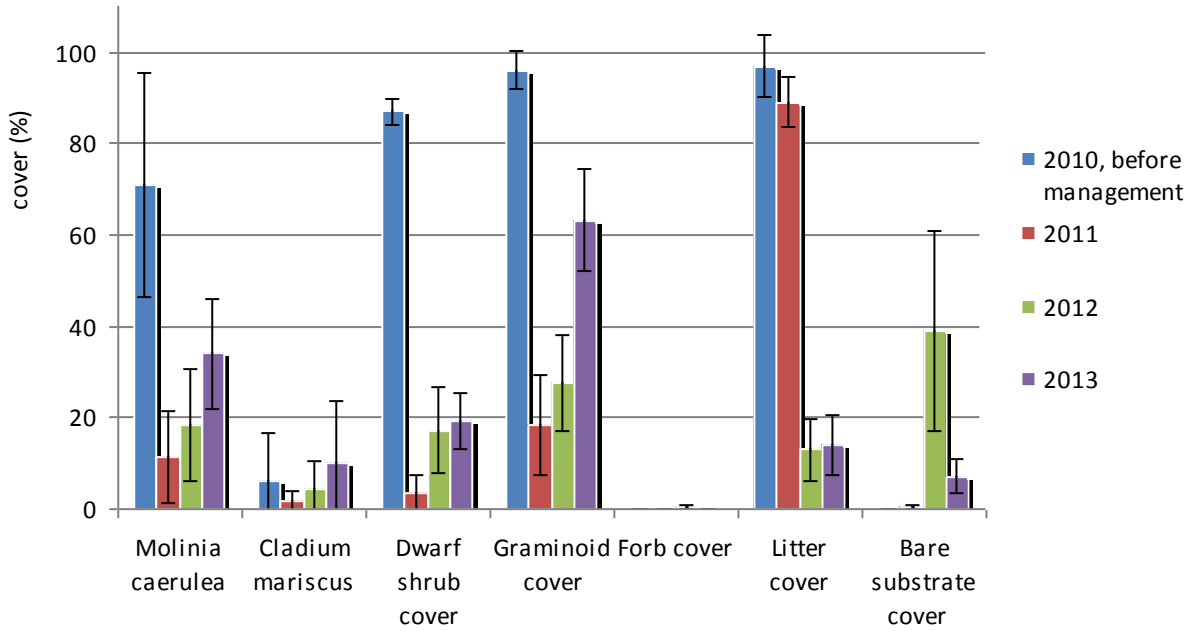


Figure 13. Changes in key vegetation attributes between 2010 and 2013; Nant Isaf (Cors Erddreiniog) ‘Before & After’ Plot 1. Error bars are 1 Standard Deviation.

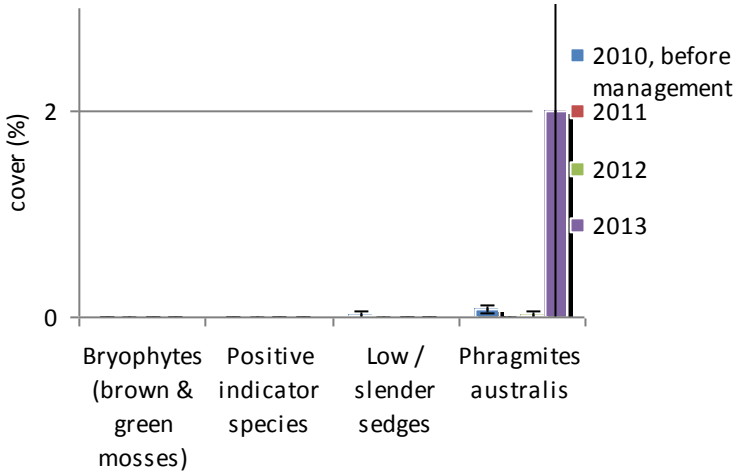


Figure 14. Changes in the cover of positive indicator species and low/slender sedges between 2010 and 2013; Nant Isaf (Cors Erddreiniog) 'Before & After' Plot 1. Error bars are 1 Standard Deviation.

Table 11. Direction and significance (*P<0.05*) of changes in key vegetation attributes between 2010 and 2013; Nant Isaf (Cors Erddreiniog) 'Before & After' Plot 1.

Variable	Years	Change (+/-)
Bryophytes	N/A	N/A
Positive indicator species	N/A	N/A
Low / slender sedges	N/A	N/A
Phragmites australis	N/A	N/A
Molinia caerulea	2010 V's 2011 2010 V's 2013	- -
Cladium mariscus	N/A	N/A
Dwarf shrub cover	2010 V's 2011 2011 V's 2012 2010 V's 2013	- + -
Graminoid cover	2010 V's 2011 2012 V's 2013 2010 V's 2013	- + -
Forb cover	2011 V's 2012 2012 V's 2013	+ -
Litter cover	2011 V's 2012 2010 V's 2013	- -
Bare substrate cover	2011 V's 2012 2012 V's 2013 2010 V's 2013	+ - +
Vegetation height	2010 V's 2011 2010 V's 2013	- -
Species richness	2011 V's 2012	+
Species diversity	2011 V's 2012	+

'Before & After' Nant Isaf Plot 2, M25 species poor *(2010 no management, 2011 mown [C1]; 2012 cattle grazing, 2013 pony grazing).*

Molinia caerulea cover decreased sharply between 2010 and 2013. Following an initial decrease between 2010 and 2011, dwarf shrub cover has decreased overall between 2010 and 2013 but increased again between 2011 and 2012. Following a decrease in graminoids between 2010 and 2011, an increase was recorded between 2011 and 2012. This resulted in no significant change overall between 2010 and 2013. Litter cover has decreased overall between 2010 and 2013, but with some increase between the last two years of monitoring. Bare substrate cover has increased overall between 2010 and 2013. However this masks a variable inter-year response of an increase between 2010 and 2011, followed by a decrease between 2012 and 2013. Vegetation height decreased between 2010 and 2011. However, an increasing (but non-significant) trend has resulted in no overall significant change in vegetation height between 2010 and 2013. Species richness has increased overall between 2010 and 2013. This follows an increasing trend since 2011, with a significant inter-year increase between 2011 and 2012. Species diversity shows an identical profile to species richness. A reduction between 2010 and 2011 has been followed by an increase over following years. Despite the early reduction, this has resulted in an overall increase between 2010 and 2013. Low and slender sedges have recorded an increase between 2012 and 2013 and overall between 2010 and 2013.

There have been no significant changes in the cover of bryophytes, positive indicator species and forb cover.

Figure 15. Changes in key vegetation attributes between 2010 and 2013; Nant Isaf (Cors Erddreiniog) 'Before & After' Plot 2. Error bars are 1 Standard Deviation.

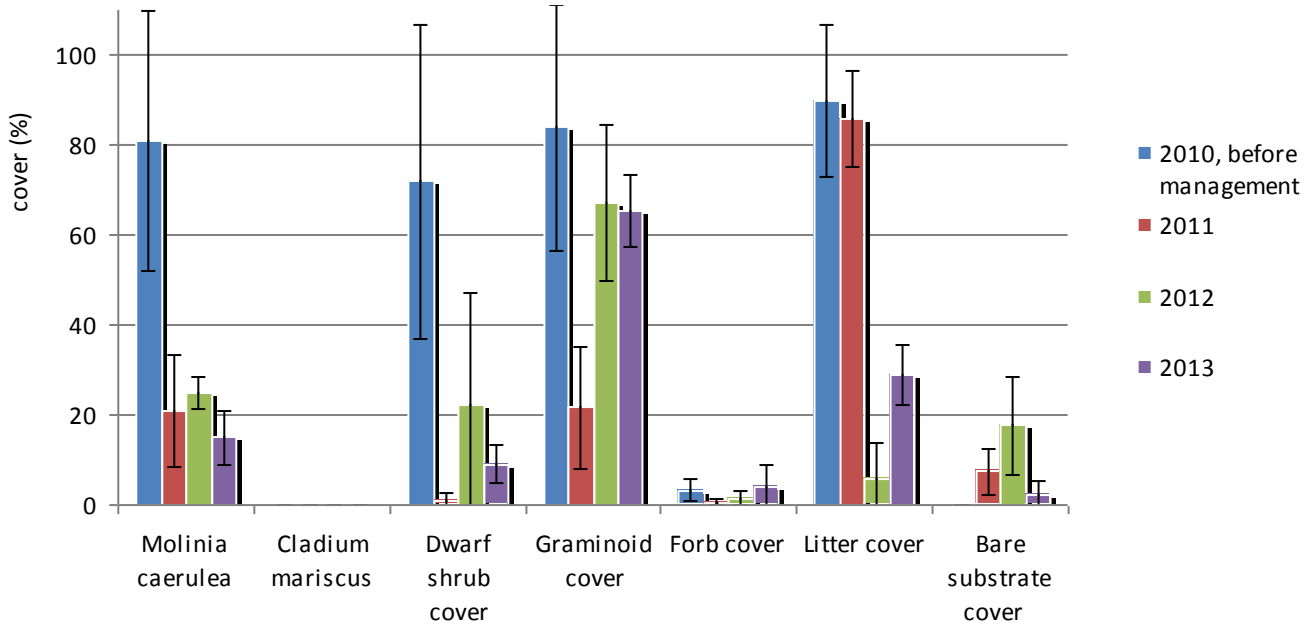


Figure 16. Changes in key vegetation attributes between 2010 and 2013; Nant Isaf (Cors Erddreiniog) 'Before & After' Plot 2. Error bars are 1 Standard Deviation.

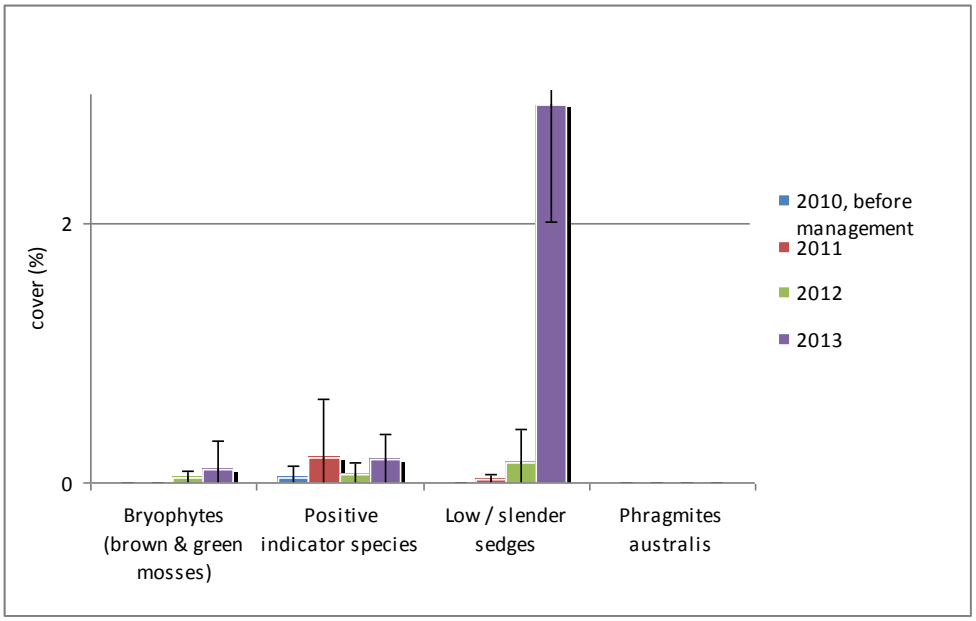
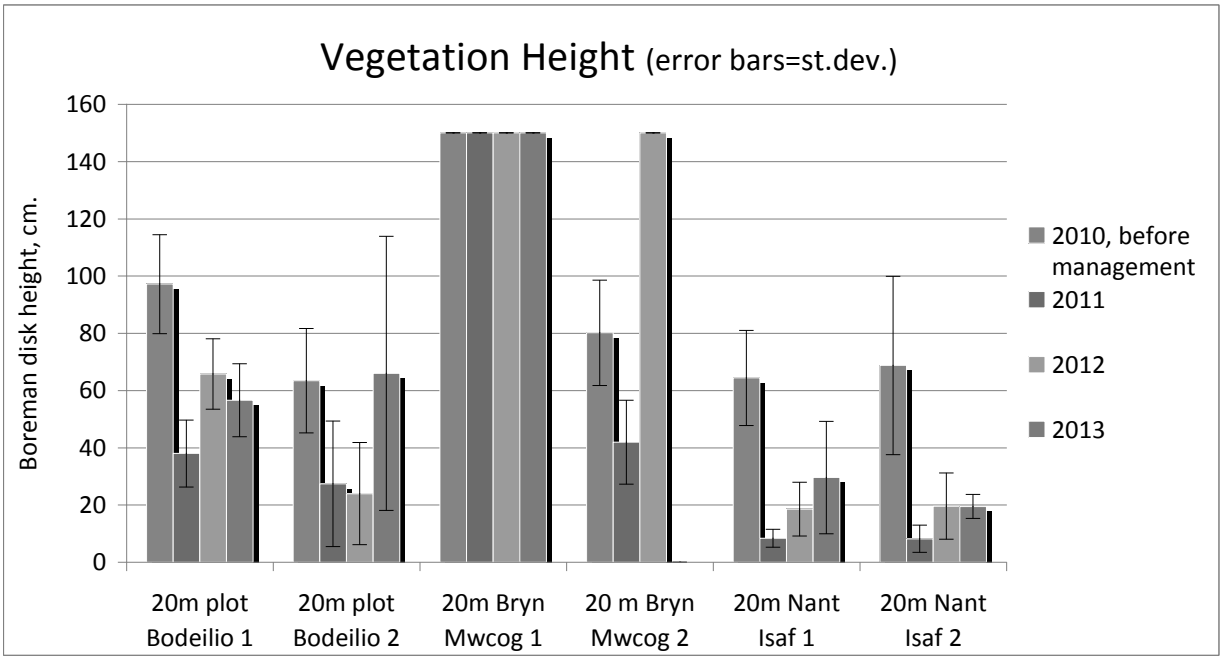
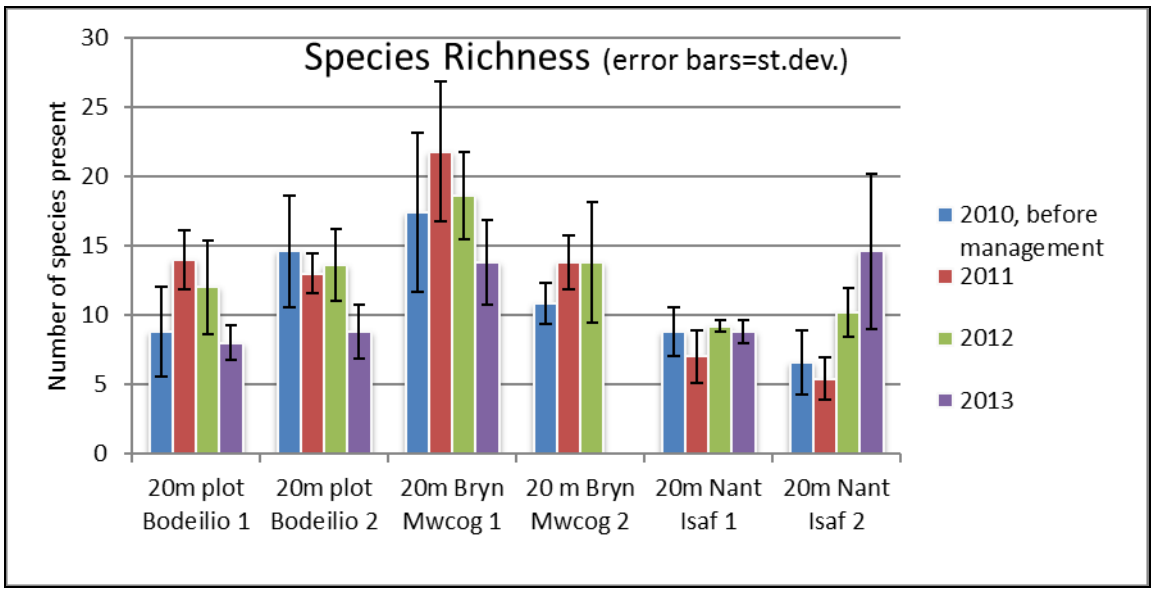


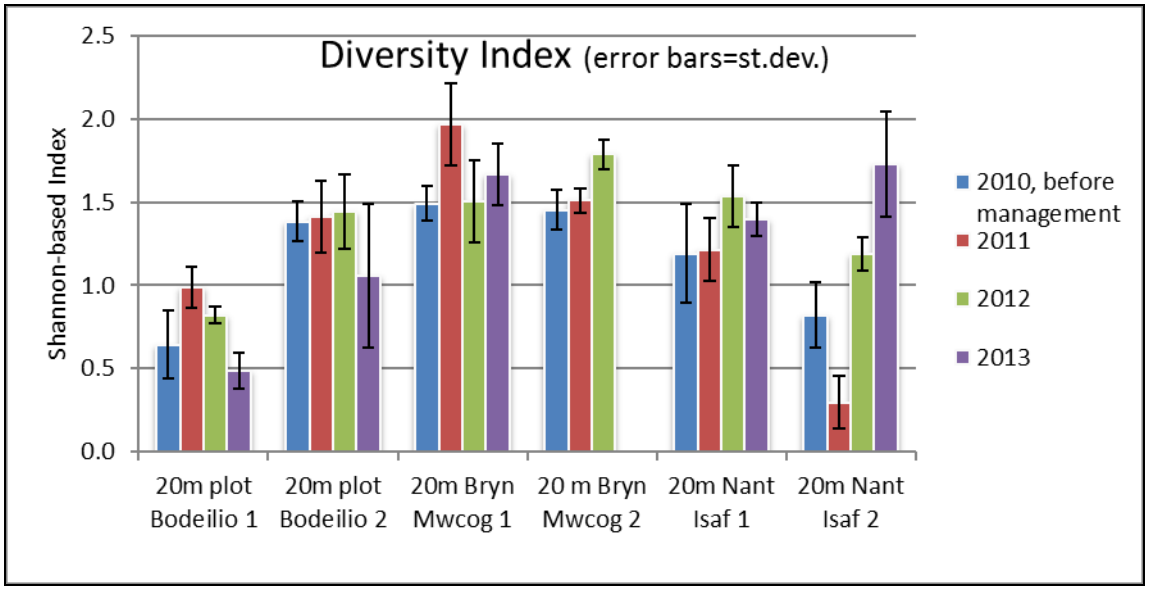
Table 12. Direction and significance (*P<0.05*) of changes in key vegetation attributes between 2010 and 2013; Nant Isaf (Cors Erddreiniog) 'Before & After' Plot 2.

Variable	Years	Change (+/-)
Bryophytes	N/A	N/A
Positive indicator species	N/A	N/A
Low / slender sedges	2012 V's 2013 2010 V's 2013	+ +
Phragmites australis	N/A	N/A
Molinia caerulea	2010 V's 2011 2012 V's 2013 2010 V's 2013	- - -
Cladium mariscus	N/A	N/A
Dwarf shrub cover	2010 V's 2011 2011 V's 2012 2010 V's 2013	- + -
Graminoid cover	2010 V's 2011 2011 V's 2012	- +
Forb cover	N/A	N/A
Litter cover	2011 V's 2012 2012 V's 2013 2010 V's 2013	- + -
Bare substrate cover	2010 V's 2011 2012 V's 2013 2010 V's 2013	+ - +
Vegetation height	2010 V's 2011	-
Species richness	2011 V's 2012 2010 V's 2013	+ +
Species diversity	2010 V's 2011 2011 V's 2012 2012 V's 2013 2010 V's 2013	- + + +

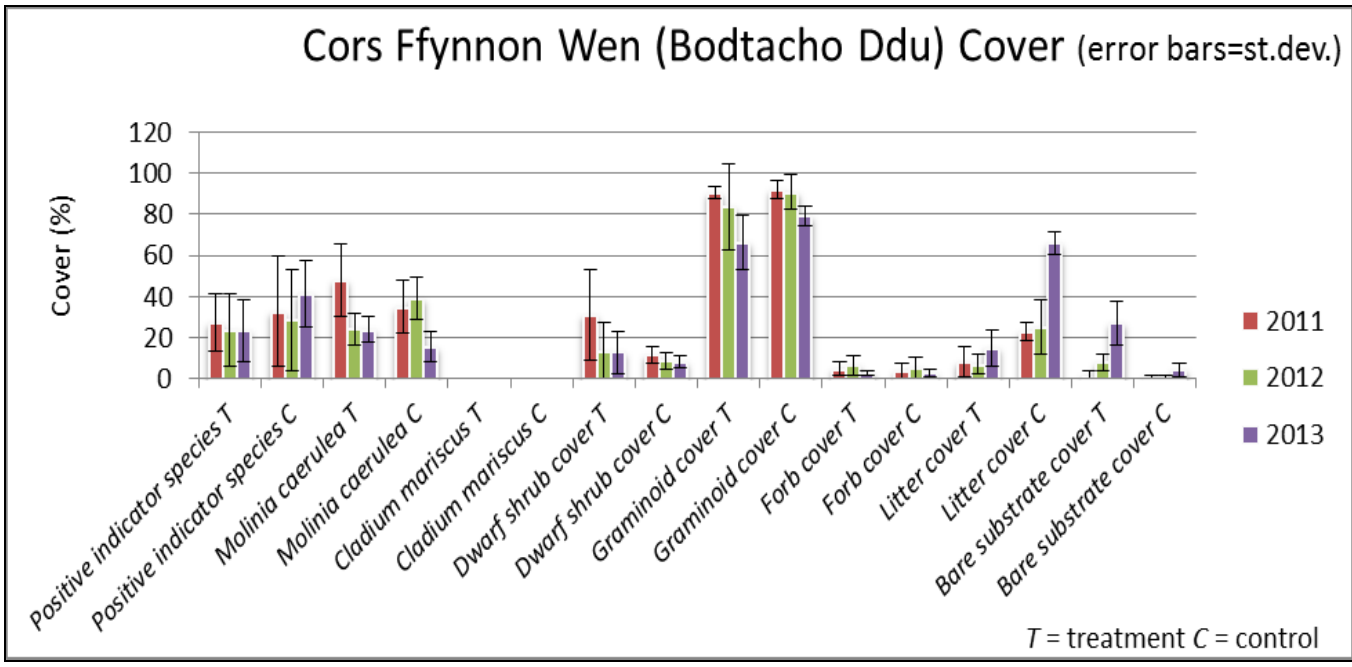
3.4. ‘Before & After’ vegetation height, species richness and diversity

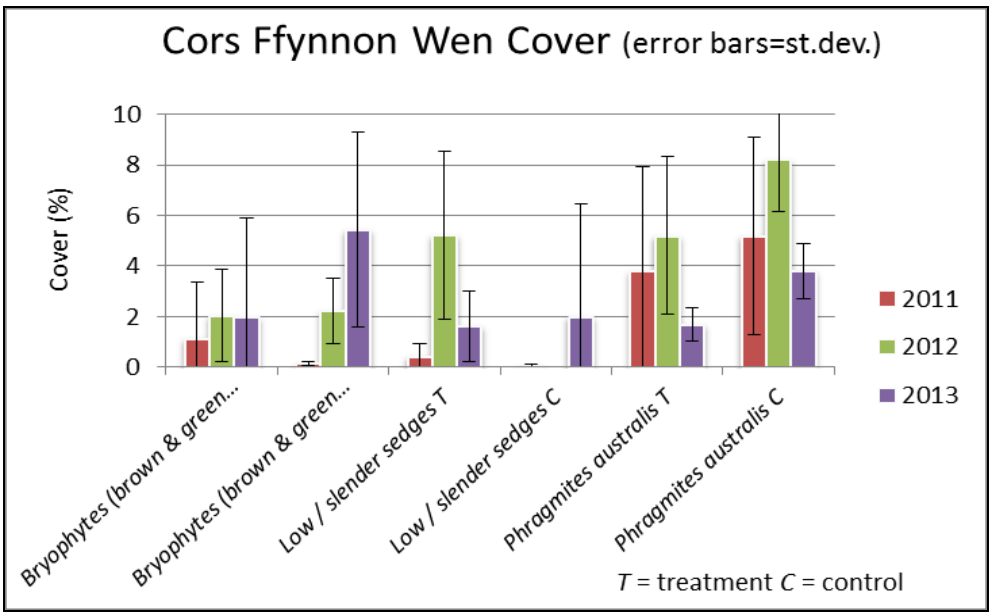





Diversity Index (error bars=st.dev.)
Shannon-based Index
2.5
2.0
1.5
1.0
0.5
0.0
20m plot Bodeilio 1
20m plot Bodeilio 2
20m Bryn Mwcog 1
20 m Bryn Mwcog 2
20m Nant Isaf 1
20m Nant Isaf 2
2010, before management
2011
2012
2013

3.5. 'Treatment & Control' Cors Geirch, Cors Ffynnon Wen (Bodtacho Ddu)





Cors Geirch, Cors Ffynnon Wen (Bodtacho Ddu): SIGNIFICANT CHANGES (*P<0.05*)						
	Treatment		**Control**		**Treatment V's Control**	
Variable	**Years**	**Change (+/-)**	**Years**	**Change (+/-)**	**Final Year Only**	**Change (+/-) (T/C)**
Bryophytes	N/A	N/A	2011 V's 2012		N/A	N/A
Positive indicator species	N/A	N/A	N/A	N/A	N/A	N/A
Low / slender sedges	2011 V's 2012	+	N/A	N/A	N/A	N/A
Phragmites australis	N/A	N/A	N/A	N/A	N/A	N/A
Molinia caerulea	N/A	N/A	2012 V's 2013 2011 V's 2013		N/A	N/A
Cladium mariscus	N/A	N/A	N/A	N/A	N/A	N/A
Dwarf shrub cover	N/A	N/A	N/A	N/A	N/A	N/A
Graminoid cover	2012 V's 2013 2011 V's 2013	- -	2012 V's 2013 2011 V's 2013	- -	N/A	N/A
Forb cover	N/A	N/A	N/A		N/A	N/A
Litter cover	N/A	N/A	2012 V's 2013 2011 V's 2013	+ +	2013	+ C
Bare substrate cover	2011 V's 2012 2012 V's 2013 2011 V's 2013	+ + +	2012 V's 2013 2011 V's 2013	+ +	2013	+ T
Vegetation height	2012 V's 2013	-	2012 V's 2013 2011 V's 2013	- -	N/A	N/A
Species	N/A	N/A	N/A	N/A	2013	+T

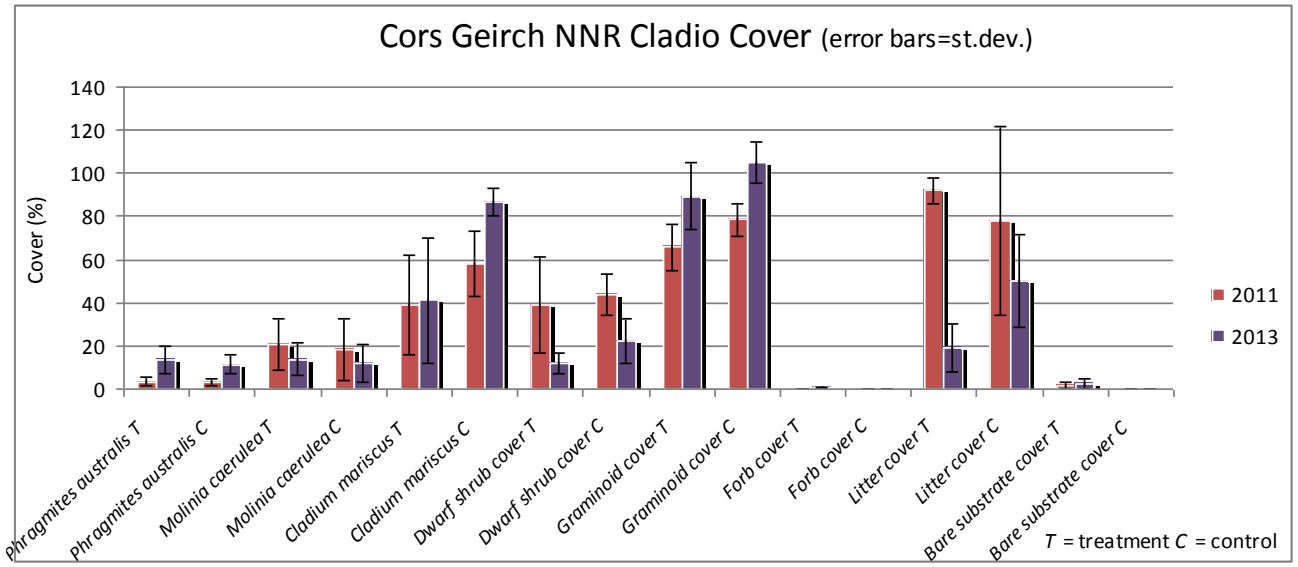
richness						
Species diversity	2011 V's 2012 2011 V's 2013	+ +	N/A	N/A	N/A	N/A

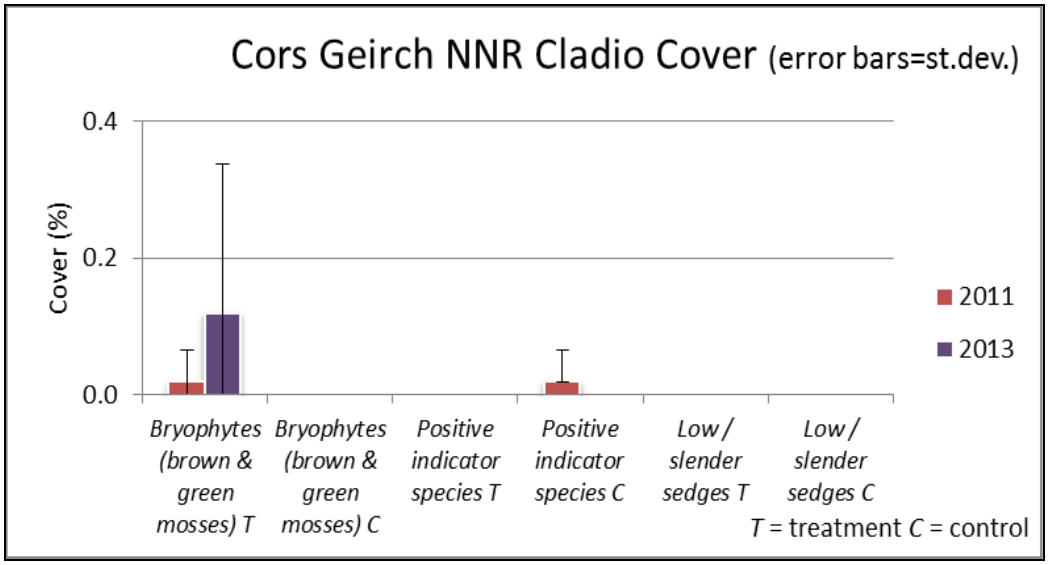
Cors Geirch, Cors Ffynnon Wen (Bodtacho Ddu) – alkaline fen

There has been no recorded change in **Bryophytes** on the Treatment Plot but an increase between 2011 and 2012 on the Control Plot. There is no difference in the cover of **Bryophytes** between Treatment and Control in 2013. **Low and slender sedges** increased between 2011 and 2012 on the Treatment Plot but no change was recorded on the Control Plot. There was also no difference in the cover of Low and slender sedges between Treatment and Control in 2013. The cover of ***Molinia caerulea*** has not changed on the Treatment Plot but recorded an inter-year decrease between 2012 and 2013 on the Control Plot. This resulted in an overall decrease in ***Molinia caerulea*** between 2011 and 2013. There was no difference in ***Molinia caerulea*** cover between Treatment and Control in 2013. **Graminoid** cover decreased inter-years between 2012 and 2013 on both the Treatment and Control plots. This also resulted in a corresponding overall decrease on both plots between 2011 and 2013. There was no difference in **Graminoid cover** between Treatment and Control in 2013. **Litter cover** has not changed in the Treatment Plot. However, on the Control plot there was an inter-year increase between 2012 and 2013. This has resulted in an overall increase between 2011 and 2013, and significantly greater Litter in The Control compared to Treatment in 2013. **Bare substrate cover** has shown a year-on-year increase in response on the Treatment Plot and an overall increase between 2011 and 2013. On the Control Plot **Bare substrate** cover also recorded an inter-year increase between 2012 and 2013. This also resulted in an overall increase between 2011 and 2012. There was a greater cover of **Bare substrate** on the Treatment Plot compared to the Control Plot in 2013. **Vegetation height** decreased on the Treatment Plot between 2012 and 2013. There was no significant difference however, between 2011 and 2013. There was a corresponding decline in Vegetation height between 2012 and 2013 on the Control Plot. In this instance, there was also a significant decline between 2011 and 2013. There was no significant difference in Vegetation height between Treatment and Control in 2013. There was no recorded change in **Species richness** on either the Treatment or Control plots. However, Species richness was greater in the Treatment Plot compared to Control in 2013. **Species diversity** increased in the inter-year period 2011 and 2012 on the Treatment Plot, and this resulted in an overall increase between 2011 and 2013. There were no changes on the Control Plot and there was no significant difference in **Species diversity** between Treatment and Control in 2013.

There have been no recorded changes in cover of **Positive indicator species**, ***Phragmites australis***, ***Cladium mariscus***, **Dwarf shrub cover** and **Forb cover**.

‘Treatment & Control’ Cors Geirch CG-NNR-Cladio





Cors Geirch NNR calcareous fen: SIGNIFICANT CHANGES (*P<0.05*)						
	Treatment		Control		Treatment V's Control	
Variable	**Years**	**Change (+/-)**	**Years**	**Change (+/-)**	**Final Year Only**	**Change (+/-) (T/C)**
Bryophytes	N/A	N/A	N/A	N/A	N/A	N/A
Positive indicator species	N/A	N/A	N/A	N/A	N/A	N/A
Low / slender sedges	N/A	N/A	N/A	N/A	N/A	N/A
Phragmites australis	2011 V's 2013	+	N/A	N/A	2013	-C
Molinia caerulea	N/A	N/A	N/A	N/A	N/A	N/A
Cladium mariscus	N/A	N/A	2011 V's 2013	+	2013	+C
Dwarf shrub cover	2011 V's 2013	-	2011 V's 2013	-	N/A	N/A
Graminoid cover	N/A	N/A	2011 V's 2013	+	N/A	N/A
Forb cover	2011 V's 2013	+	N/A	N/A	N/A	N/A
Litter cover	2011 V's 2013	-	N/A	N/A	2013	+C
Bare substrate cover	N/A	N/A	N/A	N/A	N/A	N/A
Vegetation height	2011 V's 2013	-	N/A	N/A	2013	+C
Species richness	N/A	N/A	2011 V's 2013	-	2013	+T
Species diversity	N/A	N/A	N/A	N/A	2013	+T

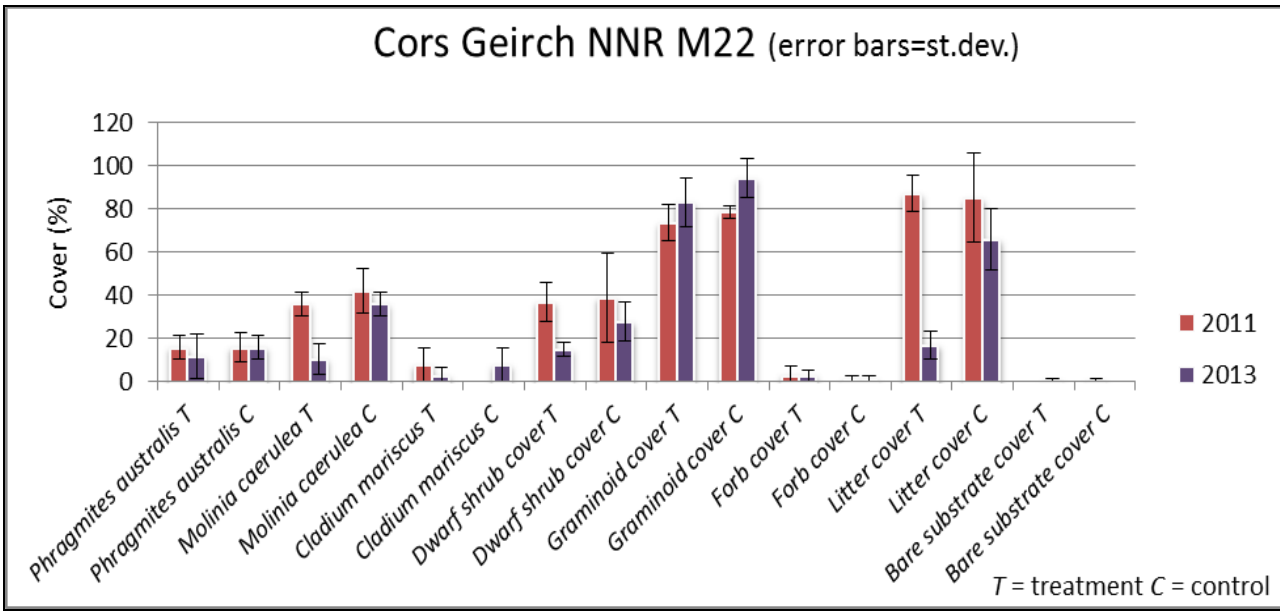
Cors Geirch NNR calcareous fen

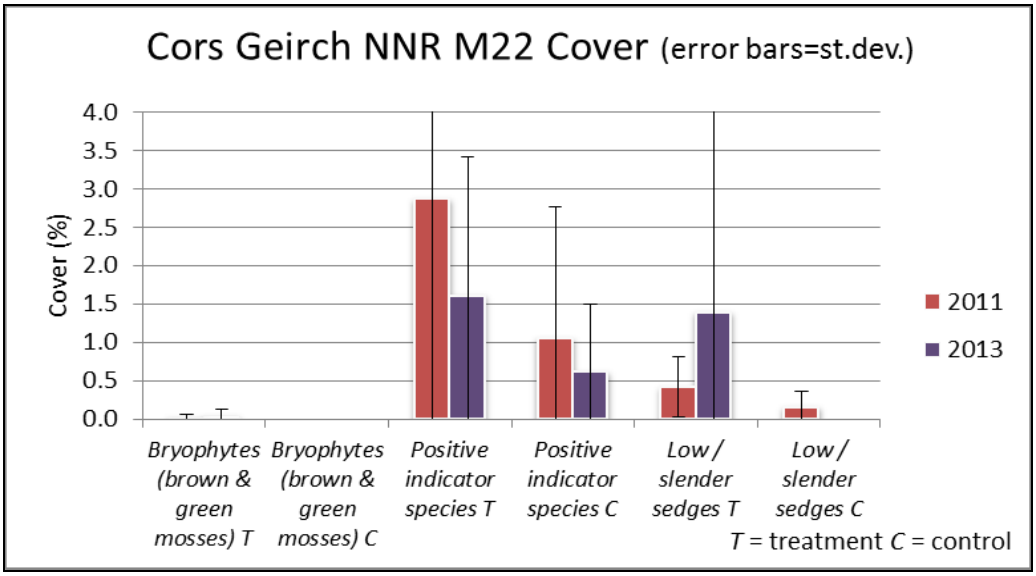
Phragmities australis increased on the Treatment Plot but there was no change on the Control Plot between 2011 and 2012. There was also less cover of *Phraagmities australis* on the Control Plot in comparision to Treatment 2013. ***Cladium mariscus*** did not change on the Treatment Plot between 2011 and 2013. However, it increased on the Control Plot. There was also a greater cover of *Cladium mariscus* on the Contol compared to Treatment in 2013. **Dwarf shrub cover** decreased between 2011 and 2013 in both Treatment and Control Plots. There was no difference in Dwarf shrub cover between plots in 2013. There was no change in **Graminoid cover** in the Treatment Plot. However, an increase occurred in the Control Plot between 2011 and

2013. There was however, no significant difference in Graminoid cover in 2013 between both plots. **Forb cover** increased between 2011 and 2013 in the Treatment Plot. This is in contrast to the Control Plot where there was no change. There was no recorded significant difference in Forb cover between the plots in 2013. There was a recorded decrease in **Litter cover** between 2011 and 2013 in the Treatment Plot, while in the Control Plot no change occurred. There was significantly more Litter cover in the Control compared to Treatment in 2013. There was an decrease in **Vegetation height** between 2011 and 2013 in the Treatment Plot, but no change in the Control Plot. Vegetation height was greater in the Control in comparison to Treatment Plot in 2013. There was no recorded change in **Species richness** in the Treatment Plot between 2011 and 2013. However, in the Control Plot there was a decrease. There was greater Species richness in the Treatment Plot compared to Control in 2013. There was no change in **Species diversity** between years in either plots between 2011 and 2013. However, Species diversity was less in Control compared to Treatment in 2013.

There have been no recorded changes in cover of **Bryophytes**, **Positive indicator species**, **Low and slender sedges**, ***Molinia caerulea*** and **Bare substrate cover**.

‘Treatment & Control’ Cors Geirch CG-NNR-M22




Cors Geirch NNR M22 Cover (error bars=st.dev.)
Cover (%)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Bryophytes (brown & green mosses) T
Bryophytes (brown & green mosses) C
Positive indicator species T
Positive indicator species C
Low / slender sedges T
Low / slender sedges C
2011
2013
T = treatment C = control

Cors Geirch NNR – fen meadow (M22): SIGNIFICANT CHANGES (*P<0.05*)						
	Treatment		Control		Treatment V's Control	
Variable	**Years**	**Change (+/-)**	**Years**	**Change (+/-)**	**Final Year Only**	**Change (+/-) (T/C)**
Bryophytes	N/A	N/A	N/A	N/A	N/A	N/A
Positive indicator species	N/A	N/A	N/A	N/A	N/A	N/A
Low / slender sedges	N/A	N/A	2011 V's 2013	-	N/A	N/A
Phragmites australis	N/A	N/A	2011 V's 2013	+	2013	+C
Molinia caerulea	2011 V's 2013	-	N/A	N/A	N/A	N/A
Cladium mariscus	N/A	N/A	N/A	N/A	N/A	N/A
Dwarf shrub cover	2011 V's 2013	-	N/A	N/A	N/A	N/A
Graminoid cover	N/A	N/A	2011 V's 2013	+	N/A	N/A
Forb cover	N/A	N/A	N/A	N/A	N/A	N/A
Litter cover	2011 V's 2013	-	N/A	N/A	2013	+C
Bare substrate cover	N/A	N/A	N/A	N/A	N/A	N/A
Vegetation height	2011 V's 2013	-	N/A	N/A	2013	-T
Species richness	N/A	N/A	N/A	N/A	2013	+T
Species diversity	N/A	N/A	N/A	N/A	N/A	N/A

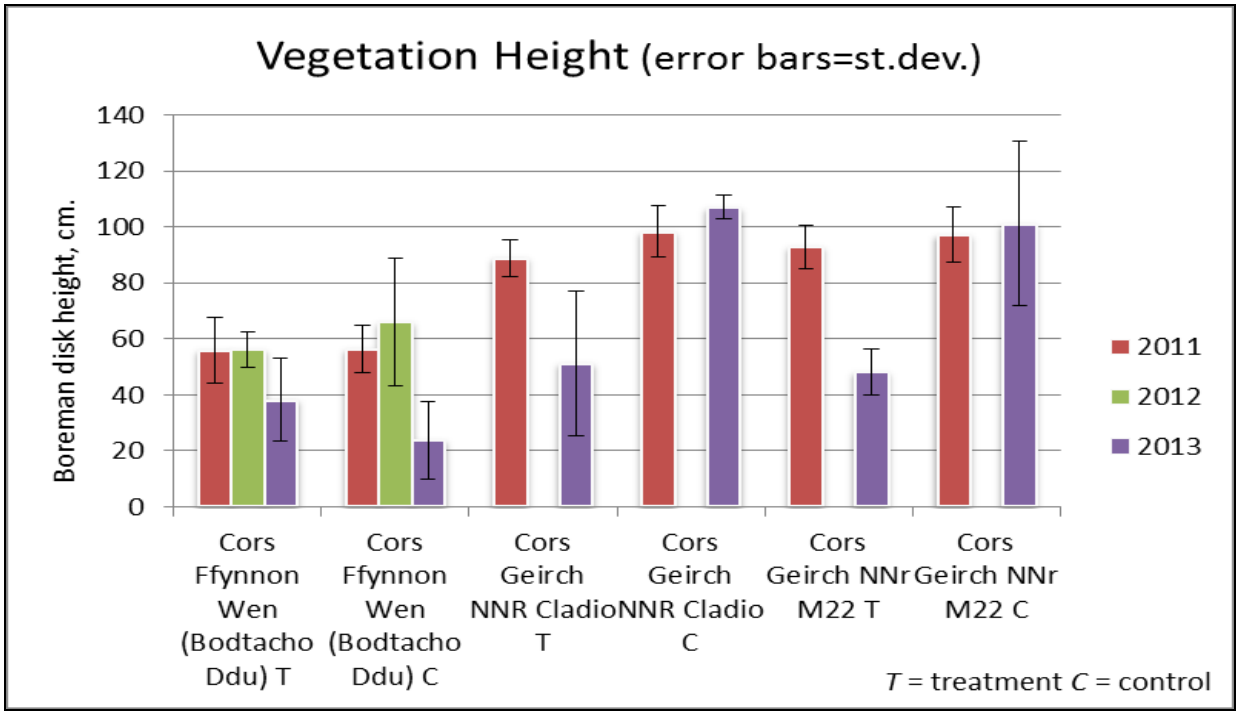
Cors Geirch NNR fen meadow (M22)

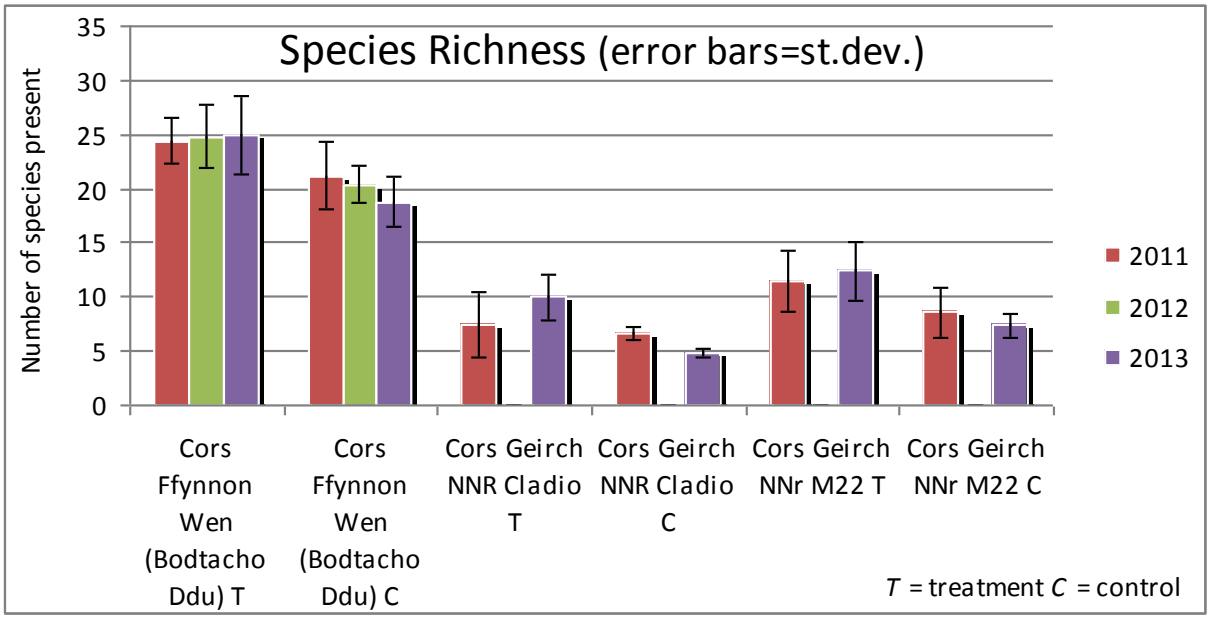
There was no change in **Low and slender sedges** in the Treatment Plot, but a decrease in cover in the Control Plot. There was no change in cover of ***Phragmites australis*** in the Treatment Plot between 2011 and 2013 but an increase was recorded in the Control. There was also a greater cover of *Phragmites australis* in the Control Plot compared to Treatment in 2013. ***Molinia caerulea*** reduced between 2011 and 2013 on the Treatment Plot but there was no recorded change on the Control Plot or between Treatment and Control in 2013. **Dwarf shrub cover** decreased between 2011 and 2013 in the Treatment Plot, but no change occurred in the Control. There was no distinction in dwarf shrub cover in 2013 between the two plots. There was no change in **Graminoid cover** between 2011 and 2013 in the Treatment Plot, but in the Control there was an increase. There was no difference in Graminoid cover between Treatment and Control in 2013. There was a reduction in **Litter cover** in the Treatment Plot between 2011 and 2013. However, the Control recorded no change.

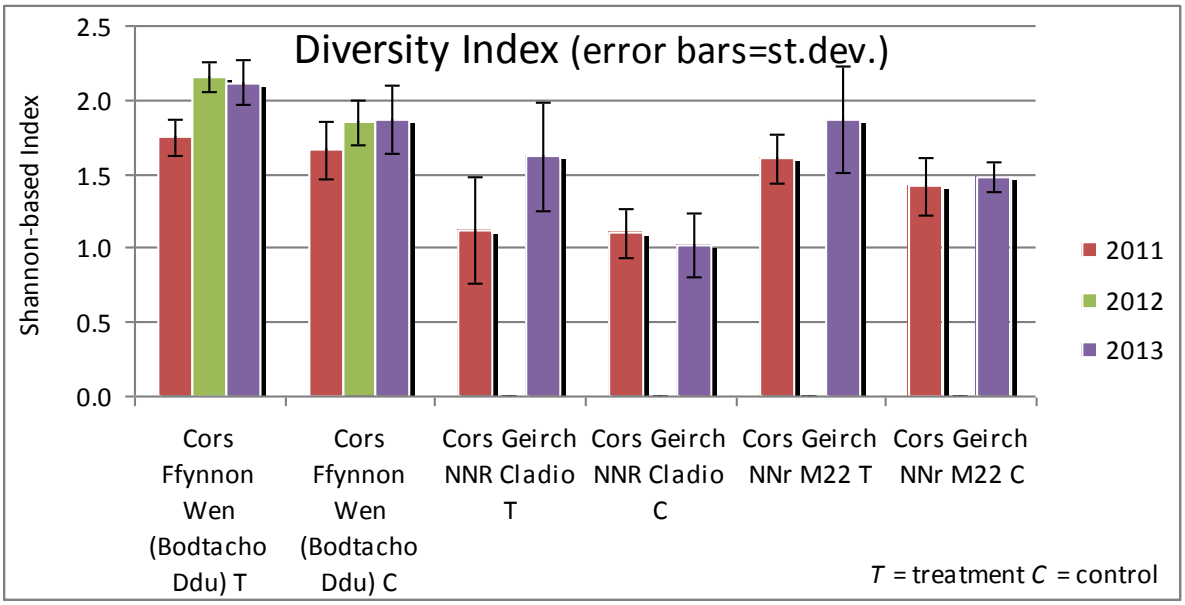
There was significantly more litter in the Control compared to Treatment in 2013. **Vegetation height** reduced in the Treatment Plot between 2011 and 2013. This is in contrast to the Control where no change was recorded. **Vegetation height** was significantly less in Treatment compared to Control in 2013. There was no recorded change in **Species richness** between years in either plot. However, in 2013 **Species richness** was greater in the Treatment compared to Control.

There have been no recorded changes in cover of **Bryophytes**, **Positive indicator species**, ***Cladium mariscus***, **Forb cover**, **Bare substrate cover** and **Species diversity**.

‘Treatment & Control’ vegetation height, species richness and diversity







C Table 6 Shannon based diversity Indices for 'Before & After' plots

Site	2010	2011	2012	2013
Cors Bodeilio Plot 1	0.644	0.988	0.821	0.488
Cors Bodeilio Plot 2	1.385	1.411	1.442	1.055
Bryn Mwcog Plot 1	1.493	1.971	1.502	1.668
Bryn Mwcog Plot 2	1.454	1.511	1.788	0.000
Nant Isaf Plot 1	1.189	1.214	1.537	1.397
Nant Isaf Plot 2	0.822	0.296	1.189	1.727

C Table 7 Shannon based diversity Indices for 'Treatment & Control' plots

Site	2011	2012	2013
Cors Ffynnon Wen (Bodtacho Ddu) T	1.747	2.158	2.119
Cors Ffynnon Wen (Bodtacho Ddu) C	1.661	1.848	1.872
Cors Geirch NNR Cladio T	1.240	N/A	1.622
Cors Geirch NNR Cladio C	1.242	N/A	1.069
Cors Geirch NNR M22 T	1.935	N/A	1.866
Cors Geirch NNR M22 C	1.697	N/A	1.480

Discussion

'Before & after' Nant Isaf Plots 1 and 2

Molinia caerulea fen meadow (M25a (_Cladium_) and M25 species-poor (_Myrica_))

On both of these plots, machine mowing was carried out in October 2010, followed by light cattle grazing and pony grazing.

This has resulted in reductions in **Litter cover** and **Graminoid** cover on both plots. As with Cors Erddreiniog, Bryn Mwcog Plots 1 and 2, there has been a partial inter-year recovery in **Graminoid cover**. Interestingly, on both plots, **Litter cover** was not reduced immediately post mowing, but recorded dramatic declines in the period 2011 to 2012. This underscores, and provides clear empirical evidence, of the significance of post restoration grazing as a management tool. This is perhaps reinforced with reference to the responses of ***Molinia caerulea****,* which in contrast to Cors Erddreiniog, Bryn Mwcog Plots 1 and 2, where post mowing grazing was not carried out, has shown significant reduction in cover on both plots. This has been maintained throughout the monitoring period. The response of **Vegetation height** also provides an interesting contrast to Cors Erddreiniog, Bryn Mwcog Plots 1 and 2. At Cors Erddreiniog, Nant Isaf Plots 1 and 2, grazing seems to have kept **Vegetation height** below its pre-mowing peak throughout the monitoring period.

Although early responses are encouraging in fashioning the conditions suitable for establishment of target habitat, responses of other variables remain somewhat equivocal at this early stage. However, the lack of response of variables such as **Positive indicator species** and **Low and slender sedges** are likely to require a greater period of time due to the reasons discussed above.

‘Treatment & Control’ Cors Geirch, Cors Ffynnon Wen (Bodtacho Ddu)

Alkaline fen (M13a)

On the Treatment Plot, management has consisted of hand-strimming and scrub removal, which was carried out in February 2012. This was followed by light to medium cattle grazing from summer 2012. Management of the Control Plot has simply consisted of light to medium cattle grazing from summer 2012.

A very discernible result is the response of Litter cover. On both plots initial **Litter covers** were relatively low in comparison to other monitored plots. However, within the Treatment Plot, **Litter cover** has not significantly changed, whereas there has been an increase in the Control Plot. This is likely due to the hand-strimming carried out on the Treatment Plot which has allowed greater access by grazing stock. This inference is reinforced by the difference in litter between Treatment and Control in 2013, and the graphical demonstrations which demonstrate a greater magnitude of increasing change in the Control Plot. A similar response profile is demonstrated by **Bare substrate** cover, which has increased on the Treatment Plot in all years. This may also be indicative that grazing stock are able to penetrate the sward more readily than on the Control. Nevertheless, this is confused somewhat by a single inter-year rise in **Bare substrate** cover in the Control Plot. However, this is also tempered by plot comparison which demonstrates a greater magnitude of change in the Treatment Plot, and in conjunction with this, a greater cover of **Bare substrate** in 2013 compared to Control.

Responses of other variables remain somewhat equivocal at this early stage. For example, the apparent decrease in ***Molinia caerulea*** on the Control Plot is difficult to explain. However, this is perhaps tempered to a degree by the downward (but at this stage not statistically significant) trend, recorded on the Treatment Plot. Furthermore, the lack of significant response in variables such as **Positive indicator species**, ***Phragmites australis***, **Dwarf shrub cover** and **Forb cover** both within and between plots suggests that a greater period of monitoring is required in order to fully evaluate trends and results.

‘Treatment & Control’ Cors Geirch, CG-NNR-Cladio

Calcareous fen (‘Cladio-Molinietum’)

On the Treatment Plot, management has consisted of machine mowing, which was carried out in February 2012. This was followed by pony grazing from the same date. Management of the Control Plot has simply consisted of pony grazing from February 2012.

A conspicuous response between the Treatment and Control is the reduction in **Litter cover** that has been recorded in the Treatment Plot in 2013. It is likely that the introduction of mowing has opened up the sward to an extent that has allowed grazing stock to reduce litter to a degree not achieved on the Control Plot due to the denser sward. This conjecture is reinforced by the inter-year significant reduction of **Litter cover** recorded on the Treatment Plot. This was not replicated on the Control Plot to a significant extent. Also, significant in this respect is the reduction of **Vegetation height** on the Treatment Plot, and difference in **Vegetation height** between plots in 2013. Both of which tend to support the notion of greater access by grazing stock to the Treatment Plot.

The reduction in **Species richness** recorded in the Control Plot may also be indicative of a denser sward and subsequently less conducive conditions within the Control Plot for plant establishment. However, this would require further analysis. Although ***Phragmites australis*** increased over the monitoring period on both the Treatment and Control Plots, the greater cover on the Control compared to the Treatment in 2013 suggests that this species is responding to management. Similarly, the increase recorded in ***Cladium*** on the Control Plot, which was not replicated on the Treatment Plot, suggests that management is controlling the spread of this species on the Treatment Plot. However, machine mowing was carried out on the Treatment Plot in 2012, and no change has been recorded in the Treatment Plot between 2011 and 2013, The possibility exists therefore, that ***Cladium mariscus*** has recovered post cutting on the Treatment Plot, (and prior to monitoring), and that in order to maintain optimum sward conditions, grazing intensity may need to be reviewed.

Responses of other variables remain somewhat equivocal at this early stage. For example the reduction in **Dwarf shrub** cover recorded on both plots is difficult to rationalise. Furthermore, as discussed above, the lack of significant response in variables such as **Bryophytes**, **Positive indicator species, Low and slender sedges**, ***Molinia caerulea***, and **Bare substrate cover**, both within and between plots, suggests that a greater period of monitoring is required in order to fully evaluate trends and results.

‘Treatment & Control’ Cors Geirch, CG-NNR-M22

Juncus subnodulosus fen meadow (M22c)

On the Treatment Plot, management has consisted of machine mowing, which was carried out in February 2012. This was followed by pony grazing. Management of the Control Plot has simply consisted of pony grazing from February 2012.

A striking feature of this Treatment and Control is the relative lack of change in the majority of variables over the monitoring period, and similarity between Treatment and Control. However, a clear trait to emerge is again the large reduction in **Litter cover** on the Treatment Plot. As discussed above, this is likely to be as a result of the ability of grazing

stock to penetrate the sward following machine mowing, and the fact that biomass was collected by the mowing machine and removed off site. This is not replicated on the Control Plot. Furthermore the significant difference in **Litter cover** between plots recorded in 2013 is likely to result from this factor, as starting conditions in 2011 were of a similar scale of magnitude. Lending weight to this notion of greater ease of stock access is the recorded significant increase in **Graminoid cover** on the Control Plot, reduction in **Vegetation height** on the Treatment Plot and increase in ***Phragmites australis*** cover on the Control and greater cover of ***Phragmites australis*** on the Control compared to the Treatment in 2013. All of which are indicative of the premise that the Control has received proportionately less grazing. The lack of response of ***Cladium mariscus*** in the Treatment Plot is perplexing as, management was carried out on the in February 2012, and it would be anticipated that a reduction would have been recorded. However, although there is a reducing trend, it remains not significant at this stage, and as discussed above, there is the possibility that there may have been a recovery in ***Cladium mariscus*** following management and prior to monitoring. There remains the possibility that this may require a review of grazing intensity.

As discussed above, the lack of significant response in variables such as **Bryophytes**, **Positive indicator species**, **Molinia caerulea**, **Forb cover**, **Bare substrate cover** and **Species diversity** both within and between plots, suggests that a greater period of monitoring is required in order to fully evaluate trends and results.

Conclusions

An early response to emerge across all plots that have been the recipients of intensive management operations is that there have been clear reductions in components such as **Graminoid cover**, **Litter cover**, **Dwarf shrub cover** and **Vegetation height**. In addition to which, on plots where they were found, similar reductions have occurred in ***Cladium mariscus*** and ***Molinia caerulea***. All of these are significant prerequisites for attainment of target condition. Indeed, evidence from the paired 'Treatment & Control' plots suggests that early intensive intervention in the form of machine mowing (or similar) is probably essential to allow stock to penetrate the sward. Interestingly, on the majority of plots, following the initial early reductions, there has followed a year-on-year increasing trend in many of these components. Although, in the majority of cases, this has not resulted in significant year-on-year increases or a return to pre-intensive management operation levels, it serves as a barometer of grazing effect and a potentially useful empirical tool with which to evaluate the intensity of grazing required in order to maintain conditions favourable to sward enhancement.

In spite of these significant recorded changes, responses of other components remain somewhat equivocal at this early stage, and are likely to require a greater period of time to evaluate. A monitoring report on restoring a specie-rich grassland in a the Elan valley showed mixed results in terms of species diversity over the 5 years of the project, with signs of positive progress being noted on a visit in the sixth year (Hayes *et al*., 2010). It is importance to continue monitoring for a sufficient timescale to see if the vegetation responds positively to management regimes. Hayes (2011) suggests that restoration of species-rich grassland occurs in a series of phases: Phase 1 (3-5 years) is the natural colonisation by ruderal/generalist species from within the existing sward; Phase 2

(10+ years) is the establishment of mid-successional species (either naturally and/or by active seed introduction) and Phase 3 (10+ Years) onwards is the natural colonisation or repeated introductions of late-succesional 'specialist' species. This carries on over several years until the target level is reached. Findings from this and other studies listed in the paper show that ecologically degraded grasslands need sufficient time to evolve through various stages of natural plant succession to fully attain the diverse flora and fauna of unimproved species-rich grassland. It seems reasonable to suggest that much the same process and timescales are likely to be the case with the restoration of fen, particularly species-rich *Schoenus nigricans*-dominated-alkaline fen (M13). Therefore, it is essential to continue with the vegetation monitoring for at least 10 years past the end of the LIFE project to give a full evaluation of different management techniques on the different vegetation communities, and regular annual/biannual monitoring will enable site managers to see if restoration is going in a positive direction and take remedial action if it is not.

References

ADAS (2013) *PROSIECT LIFE + CORSYDD MÔN A LLŶN ANGLESEY AND LLEYN FENS LIFE + PROJECT LIFE 07 NAT UK 000948 - Completion of Action E.401 – Undertake scientific monitoring of the response of alkaline fen and calcareous fen to applied management – habitat condition monitoring.* Report to NRW.

Hayes M.J. (2011) *Grassland restoration research: long-term field studies in mid-Wales*. Paper within Blackstock, T.H., Howe, E.A., Rothwell, J.P, Duigan, C.A and Jones, P.S (eds) (2011) Proceedings of a memorial conference for Dr David Paul Stevens, 1958-2007. Grassland ecologist and conservationist. CCW Staff Science Report no. 10/03/05, 168pp, Countryside Council for Wales.

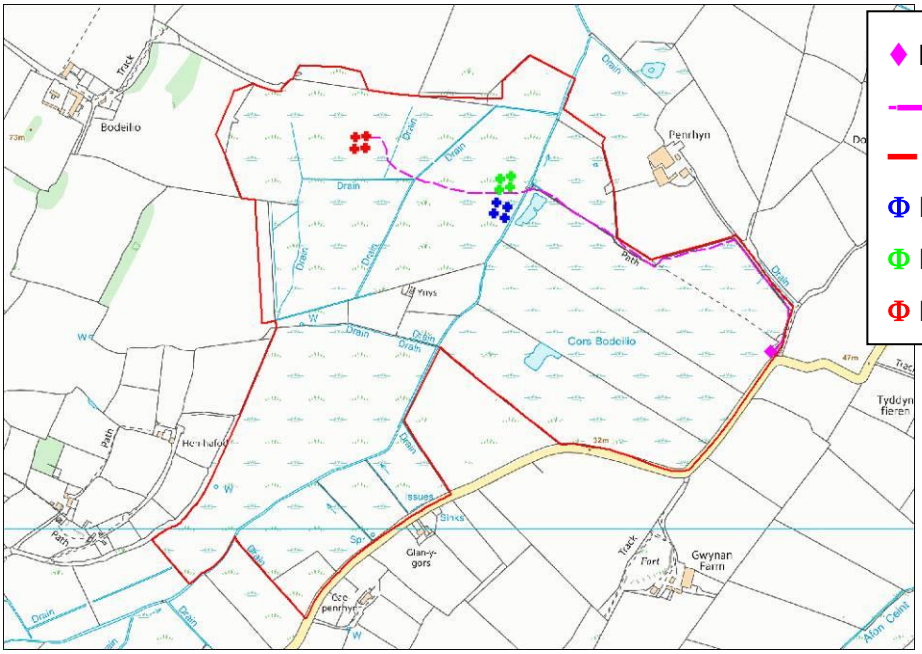
Hayes M., Lowther, R., & Elan Valley Trust (2010) *Rehabilitation and restoration of specie-rich grasslands in the elan Valley*, Radnorshire. CCW Contract Science Report 938.

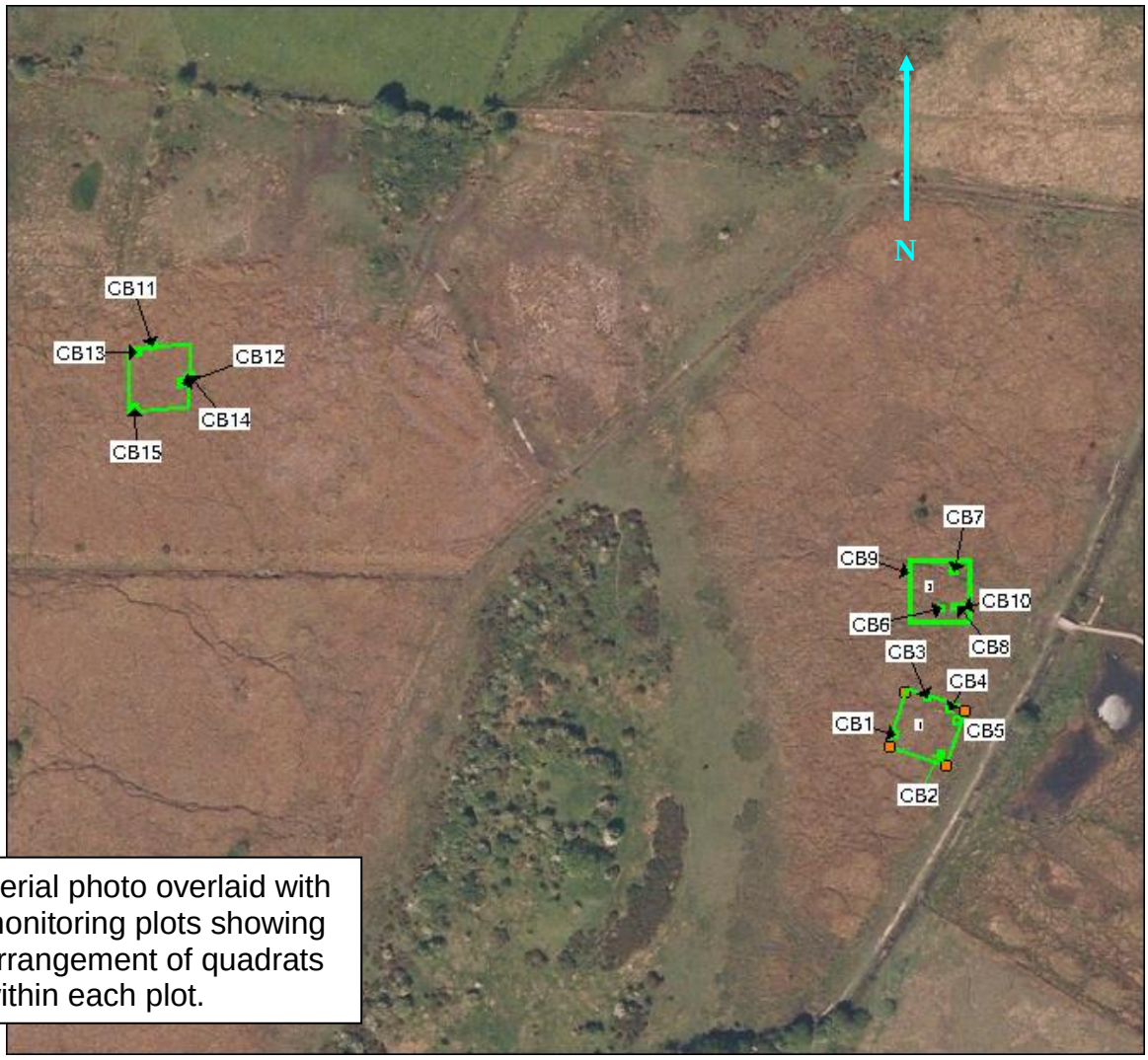
JNCC (2004) *Common Standards Monitoring Guidance for Lowland Wetlands Habitats* - Version August 2004 Updated from (February 2004)

Annex 1. Plot relocation sheets

The final section contains a series of plot relocation sheet for all monitoring covered by the LIFE Team. These should be taken into the field to aid plot and quadrat location. Location sheets covering the PhD plots will be provided in the PhD thesis.

‘Before & After’ Cors Bodelio Plots 1, 2 & 3

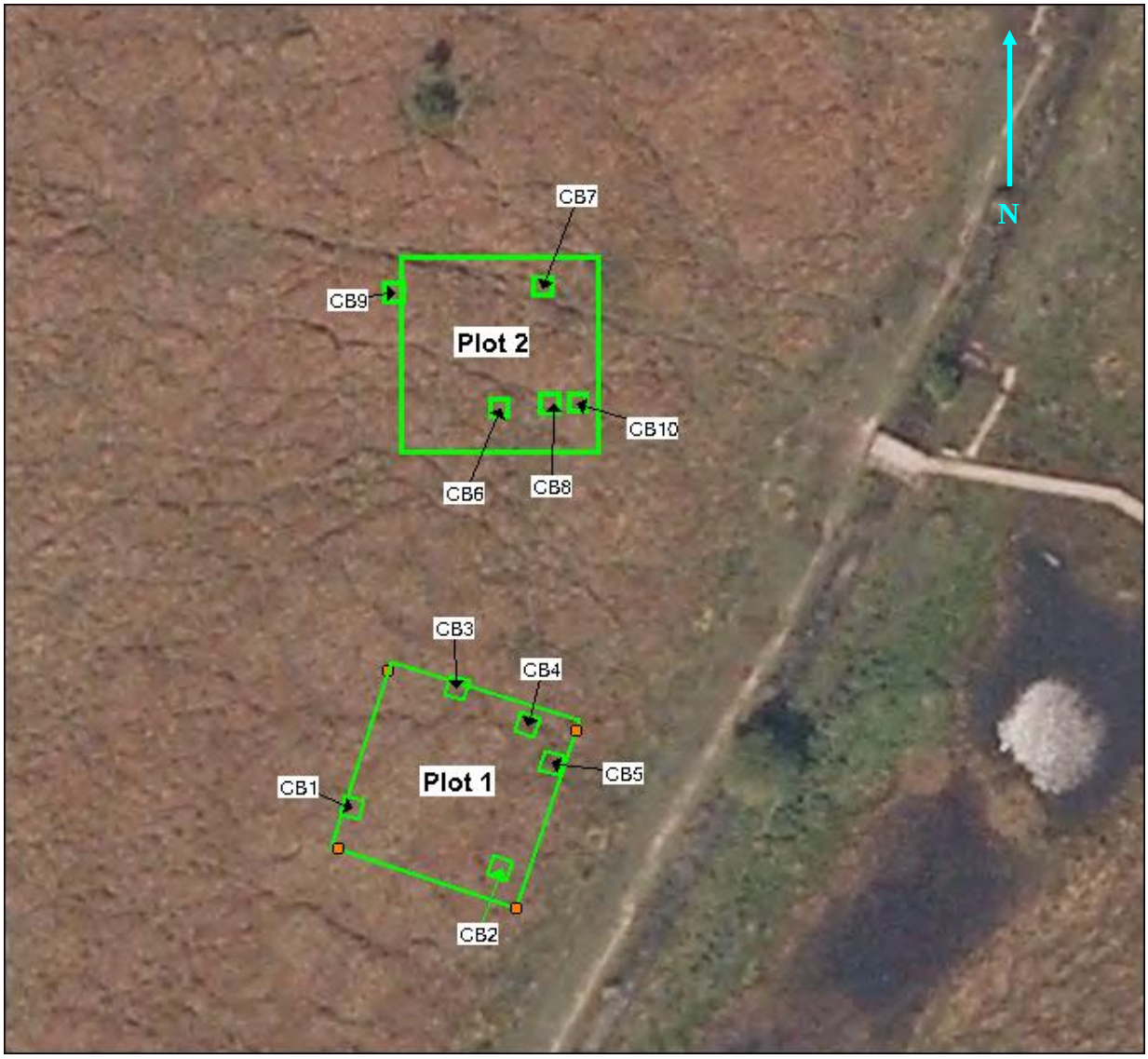




Aerial photo overlaid with monitoring plots showing arrangement of quadrats within each plot.

Natural Resources Wales, 100019741 (2014).

Location of Cors Bodeilio Plots 1 & 2 in relation to bridge over river Nodwydd



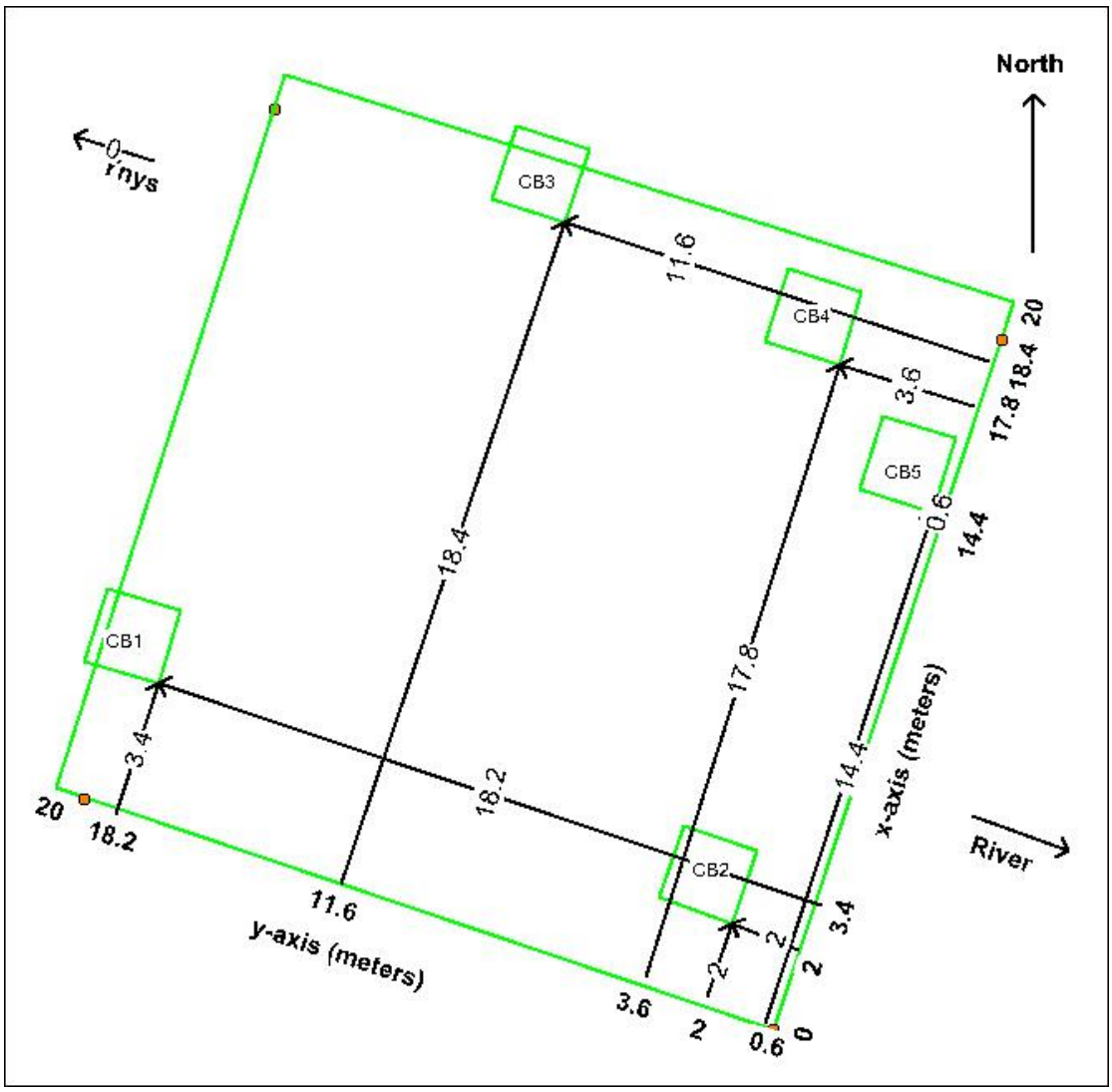
Natural Resources Wales, 100019741 (2014).

Grid references for plot corners

Plot 1		Plot 2	
NW Corner	SH50174 77565	NW Corner	SH50175 77604
NE Corner	SH50193 77559	NE Corner	SH50195 77609
SW Corner	SH50169 77547	SW Corner	SH50174 77585
SE Corner	SH50187 77541	SE Corner	SH50193 77590

Grid references were taken with a handheld Garmin GPS, so are accurate to 5m.

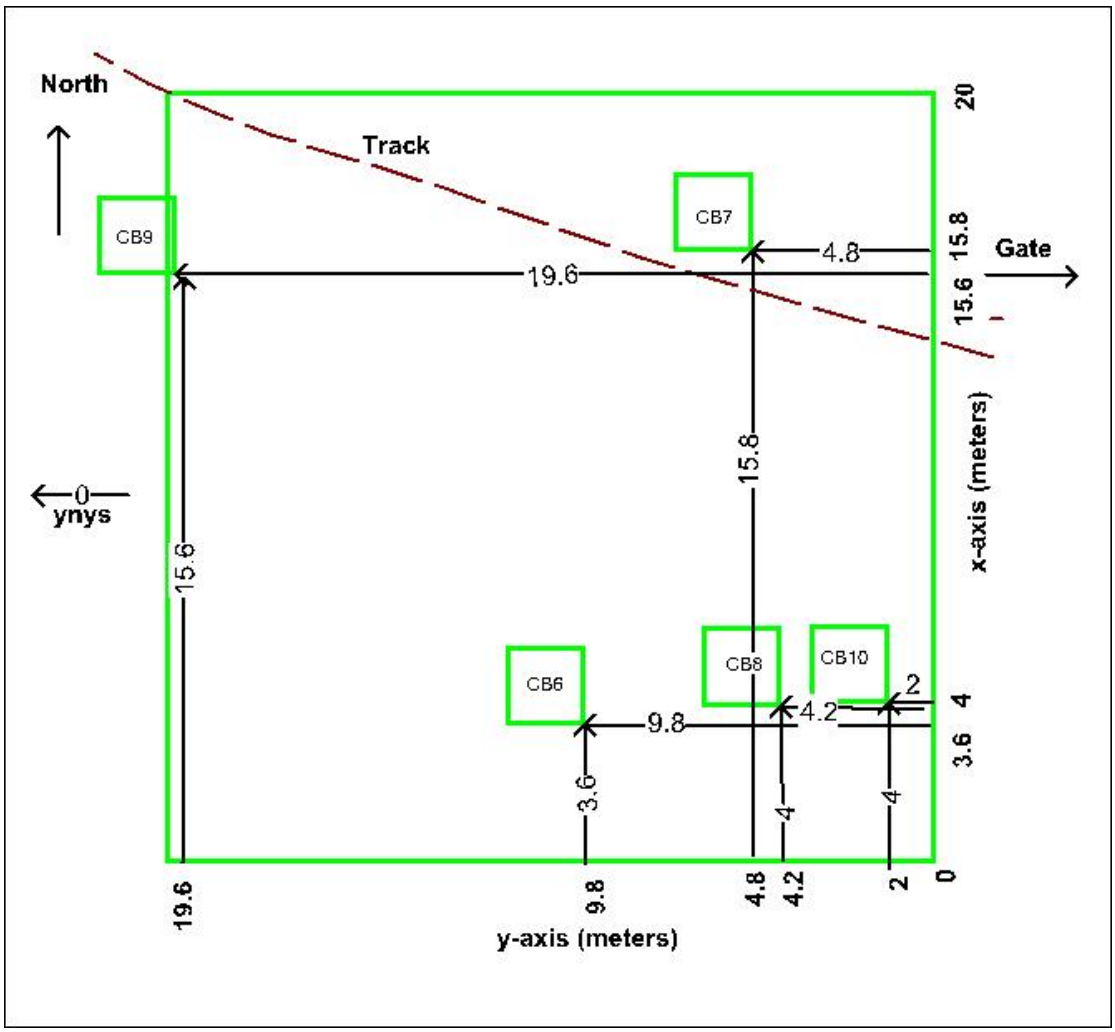
Thematic plan of quadrat locations for Cors Bodeilio: 'Before & After' Plot 1, 'Cladio-Molinietum a', Quadrats CB1-CB5



Notes for Plot 1

- Plot corners marked with steel plate and cane in section of white plastic pipe.
- Photos taken from north looking south. Label as 'Bod – Plot 1-Q[1-5]-year'.
- Measurements taken (in meters) from south east corner of plot to south east corner of each quadrat. View plot layout with river to your back, looking towards the 'ynys'**.**

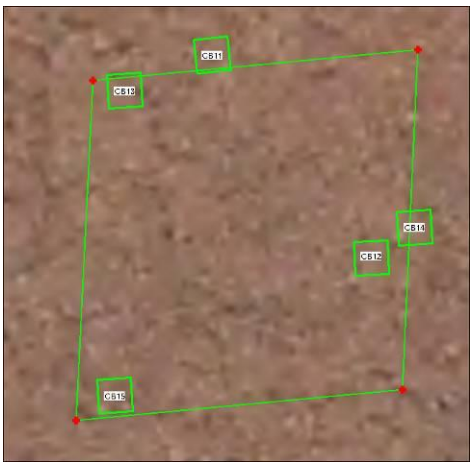
Thematic plan of quadrat locations for Cors Bodeilio: 'Before & After' Plot 2, 'Cladio-Molinietum' a, Quadrats CB6-CB10



Notes for Plot 2

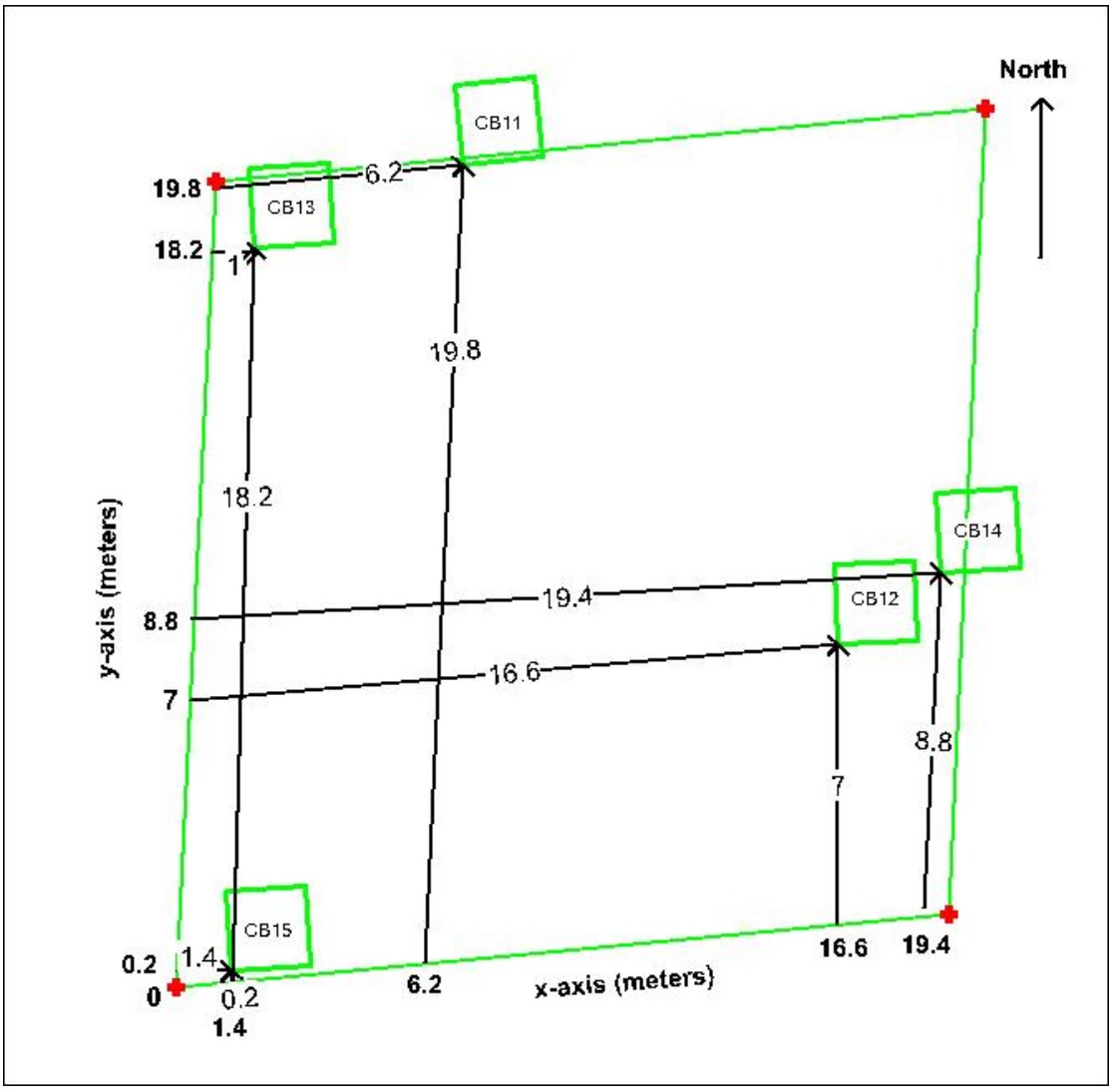
- Plot corners marked with metal plate and cane in section of white plastic pipe.
- Photos taken from north looking south. Label as 'Bod – Plot 2-Q[6-10]-year'.
- Measurements taken (in meters) from south east corner of plot to south east corner of each quadrat. View plot layout with river to your back, looking towards the 'ynys'
- Vehicle track goes through part of Plot 2.

Thematic plan of quadrat locations for Cors Bodeilio: 'Before & After' Plot 3, 'Cladio-Molinietum' a, Quadrats CB11-CB15

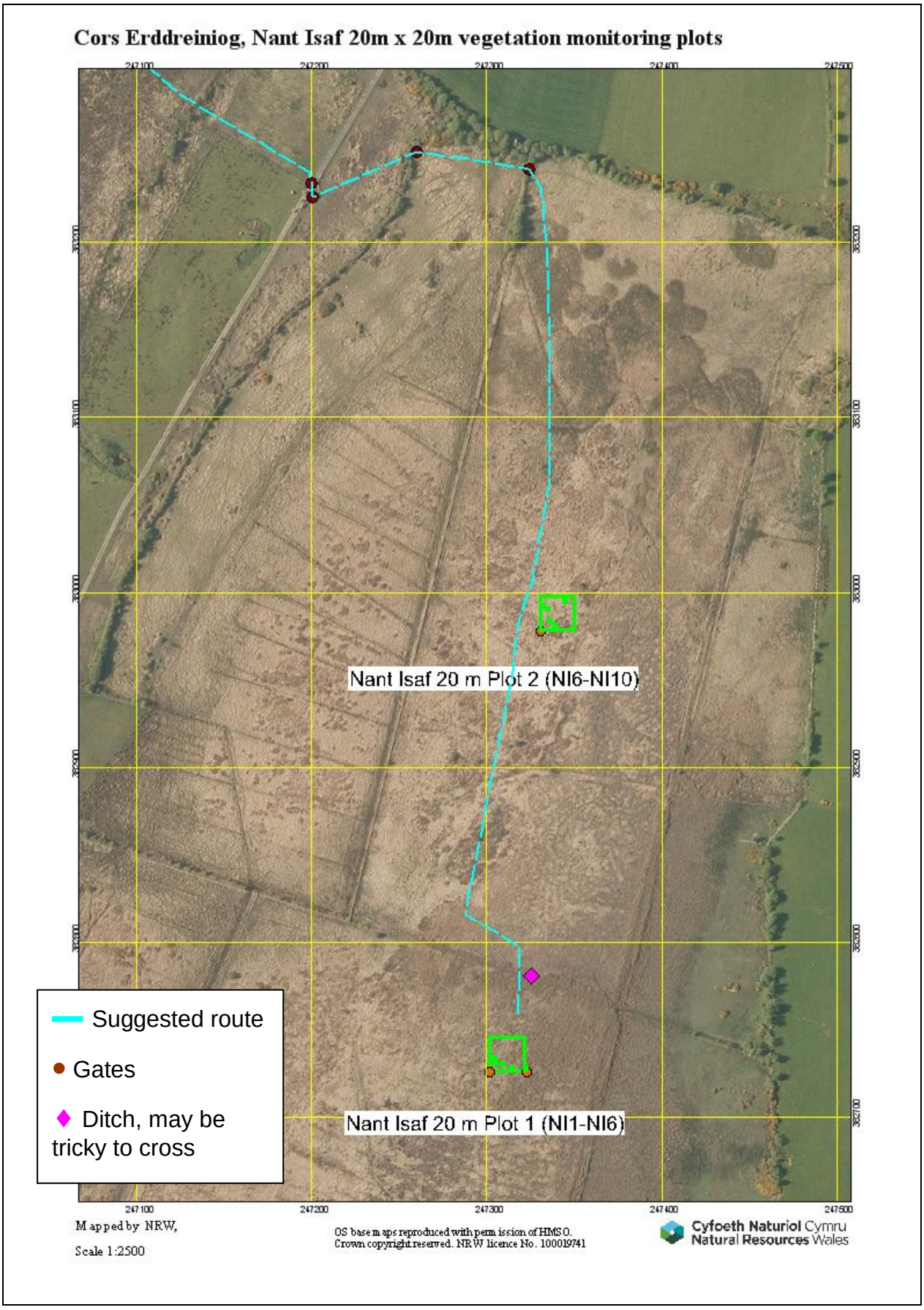


- Plot corners marked with metal plate and cane in section of white plastic pipe.
- Plot is not exactly square (due to difficulty setting up in dense *Cladium*). Measure quadrats from SW corner.
- Measurements taken (in meters) from south west corner of plot to south west corner of each quadrat.
- Photos taken from north looking south. 'Bod – Plot 2-Q[11-15]-year'.

Natural Resources Wales, 100019741 (2014).

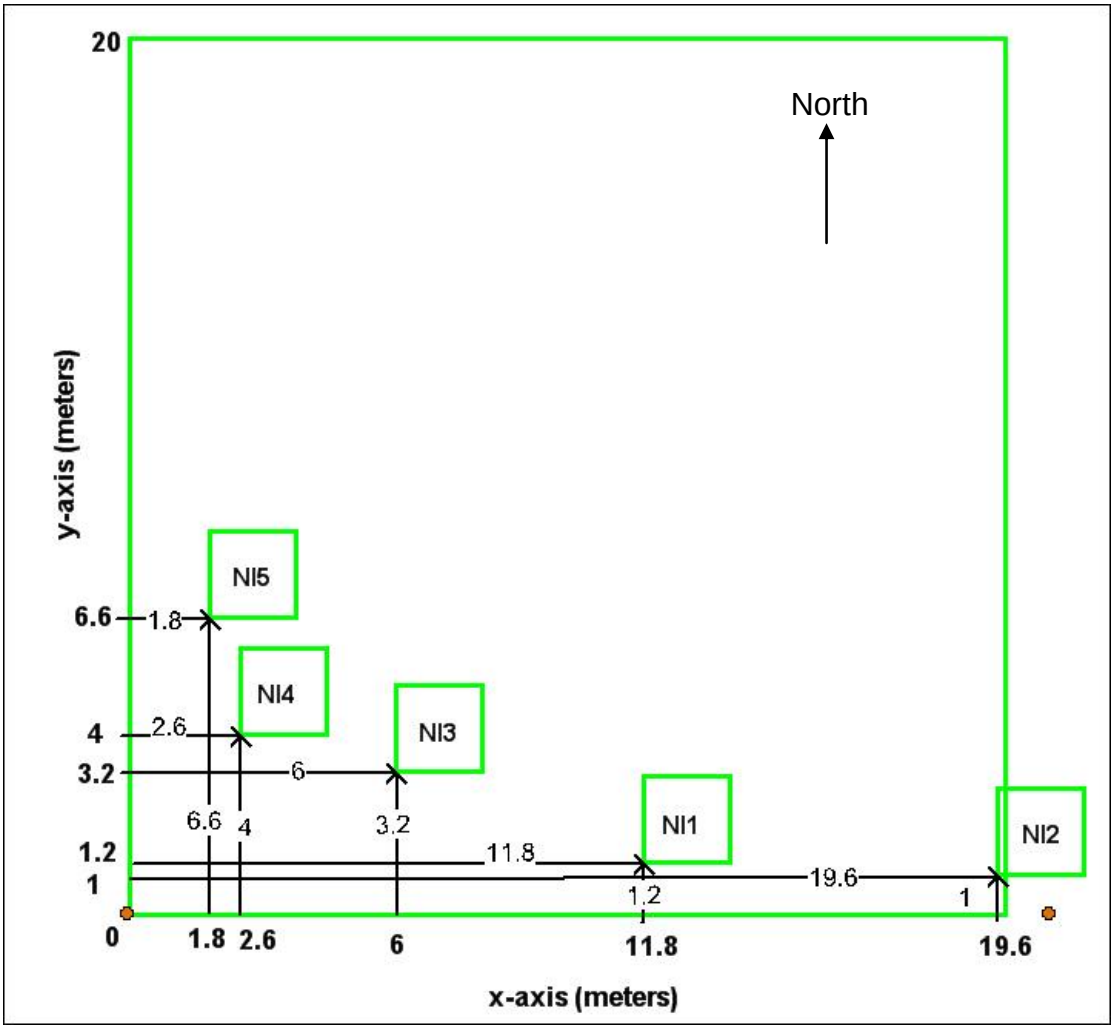


‘Before & After’ Cors Erddreiniog, Nant Isaf Plots 1 & 2



Thematic plan of quadrat locations for Cors Erddreiniog, Nant Isaf 'Before & After' Plot 1, M25a (*Cladium*, *Myrica*, *Phragmites*), Quadrats NI1 - NI5

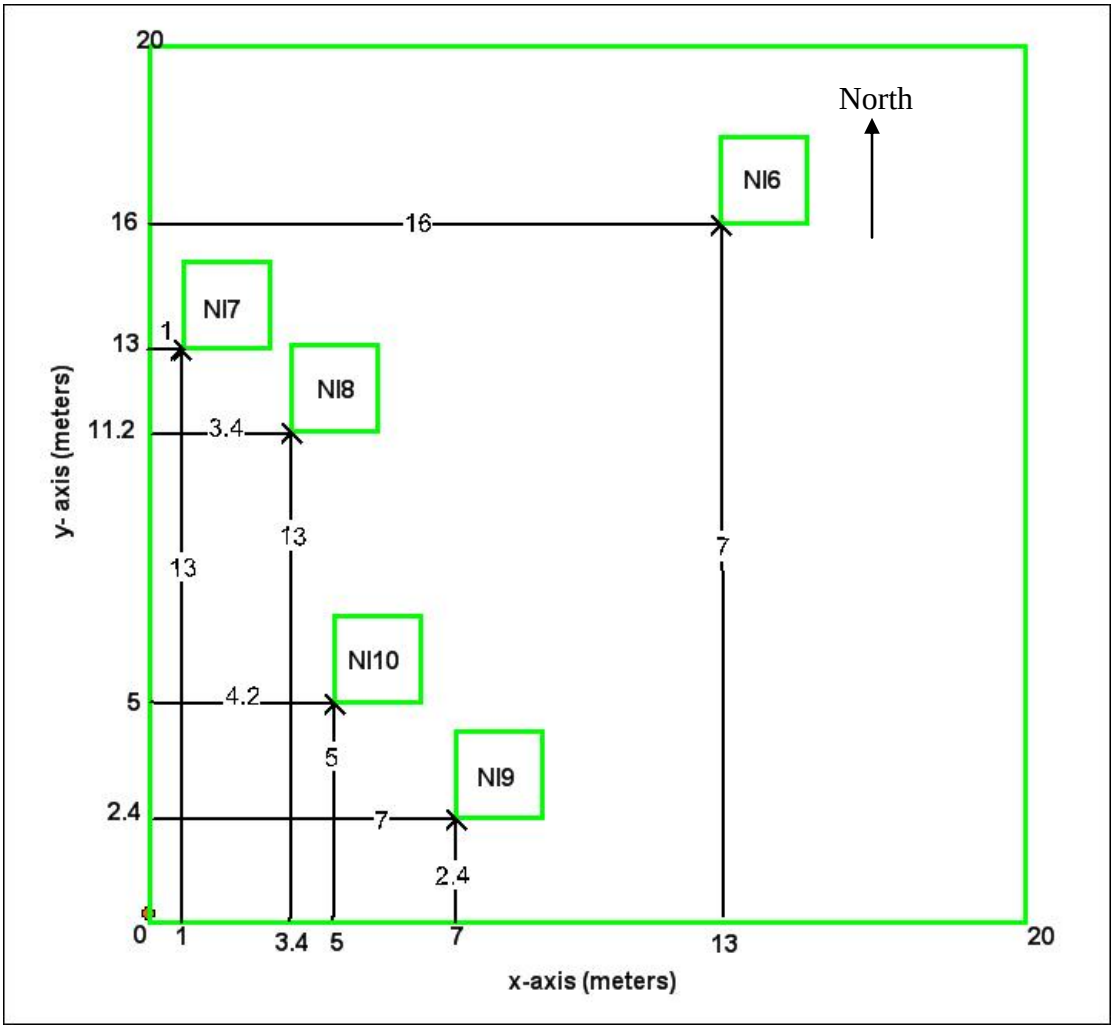
- Photos taken from north looking south. Label as 'Nant Isaf – Plot 1-QNI[1-5]-year'.
- Metal plate & cane with plastic sleeve in south west corner of plot & each quadrat.
- Measurements taken (in meters) from south west corner of plot to south west corner of each quadrat.



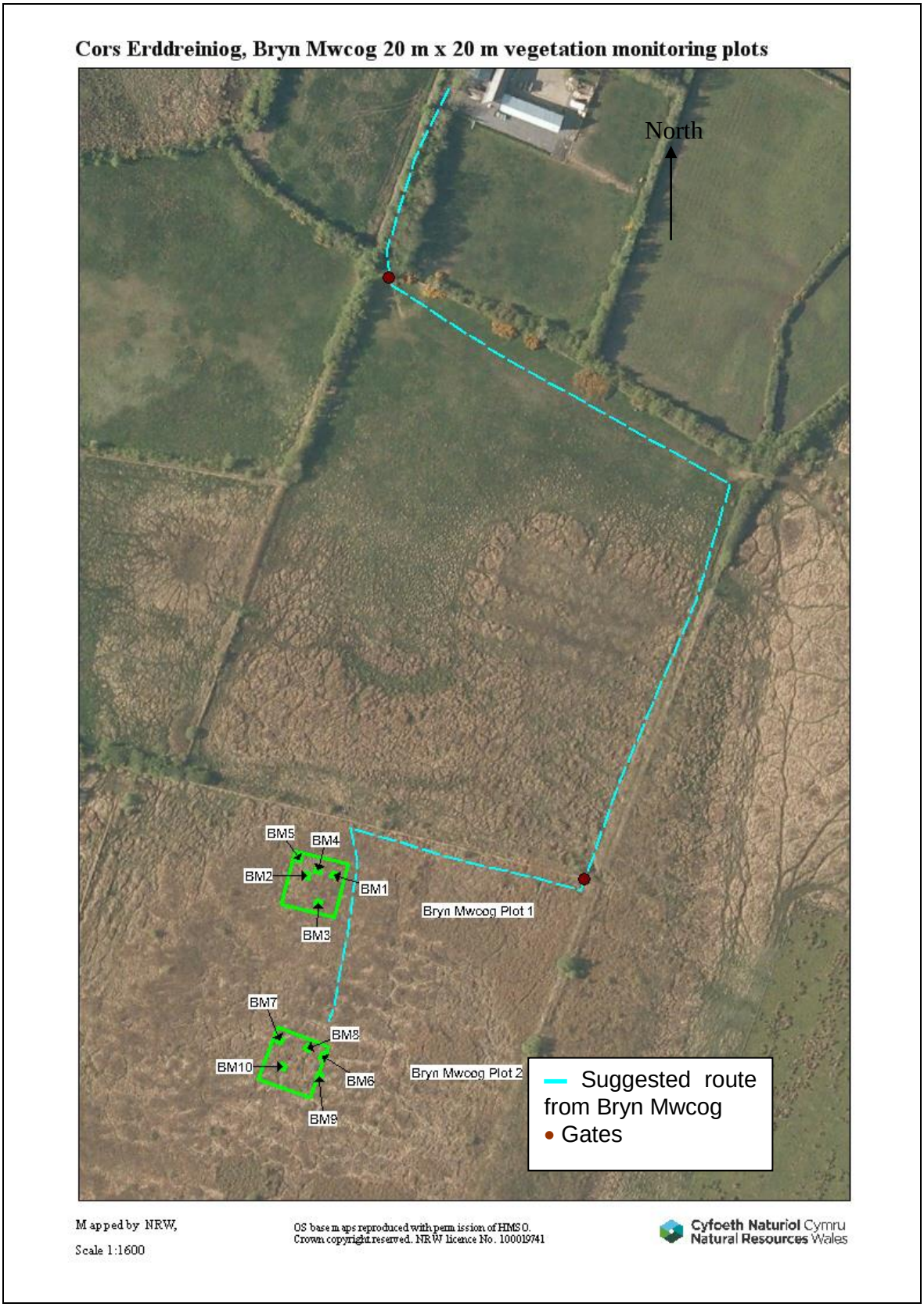
Thematic plan of quadrat locations for Cors Erddreiniog, Nant Isaf 'Before & After' Plot 2, M25 species-poor, Quadrats NI6 – NI10

- Photos taken from north looking south. Label as 'Nant Isaf Plot 2 QNI[6-510 year'.
- Metal plate & cane with plastic sleeve in south west corner of plot & each quadrat.
- Measurements taken (in meters) from south west corner of plot to south west corner of each quadrat.
- SW corner SH4733482998 (6 m)
  SE corner SH4733182978 (6 m)
  NW corner SH4385482997 (5 m)
- Measure water depth in QNI6-

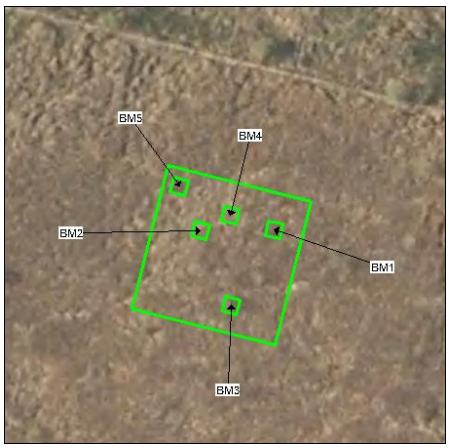
Natural Resources Wales, 100019741 (2014).



‘Before & After’ Bryn Mwcog Plots 1 & 2

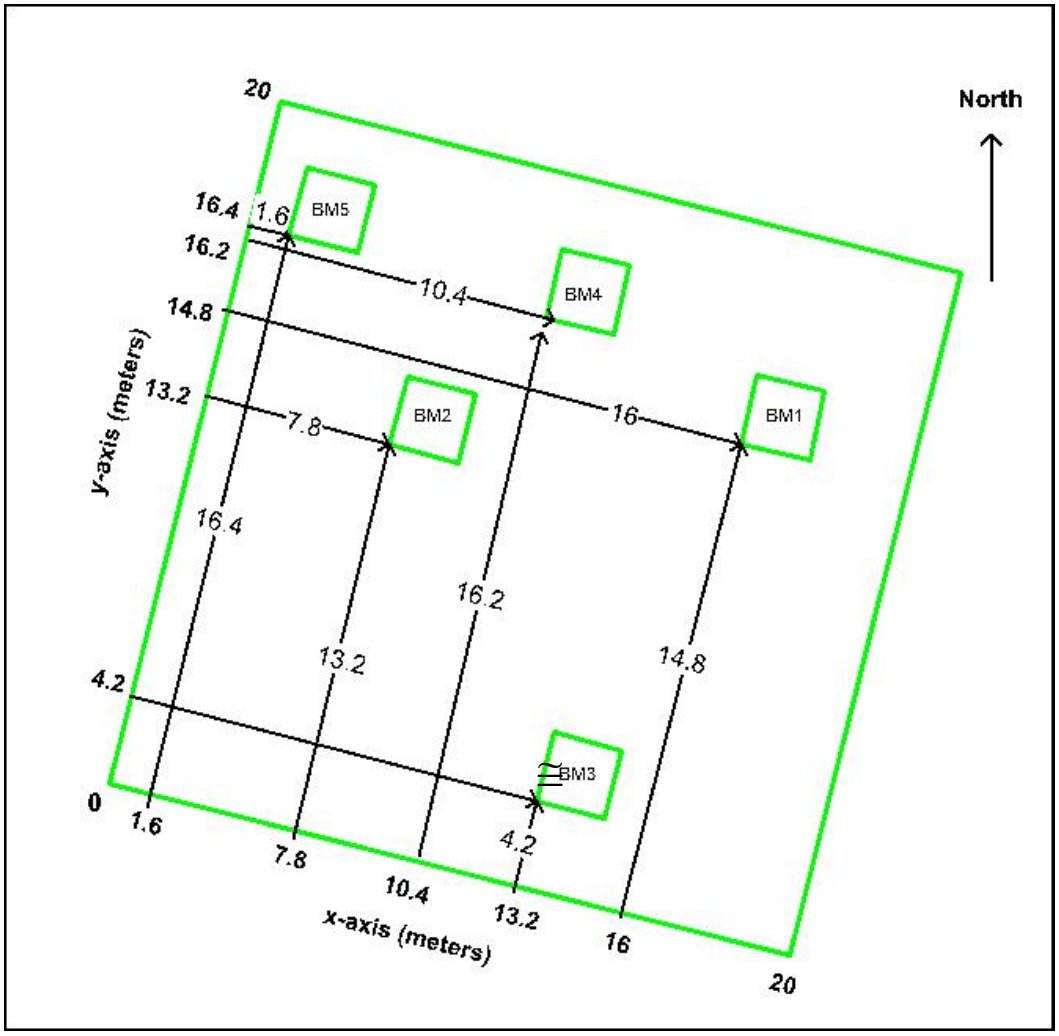


Thematic plan of quadrat locations for Cors Erddreiniog, Bryn Mwcog 'Before & After' Plot 1, M22a, Quadrats BM1 - BM5

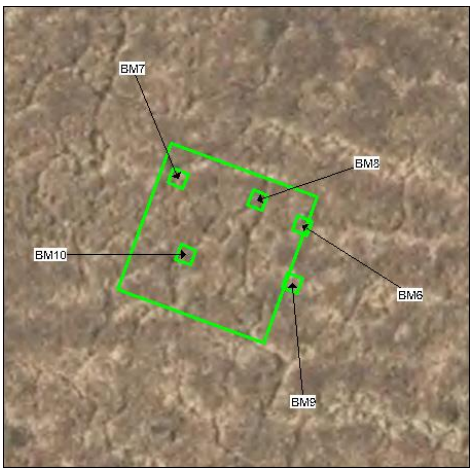


Natural Resources Wales, 100019741 (2014).

- Photos taken from north looking south. Label as 'Bryn Mwcog Plot 1 QBM[1-5]-year'.
- Metal plate & cane with plastic sleeve in south west corner of plot & each quadrat.
- Measurements taken (in meters) from 'south west' corner of plot to south west corner of each quadrat.
- ≅Willow tree by BM3.
- Vegetation may be too tall for a Boreman disc measurement.
- 'NW' corner SH4679383213 (5 m)
  'NE' corner SH4680983209 (6 m)
- Can be easier to measure the quadrats from the 'NW' to 'NE' axis, as they are closer.

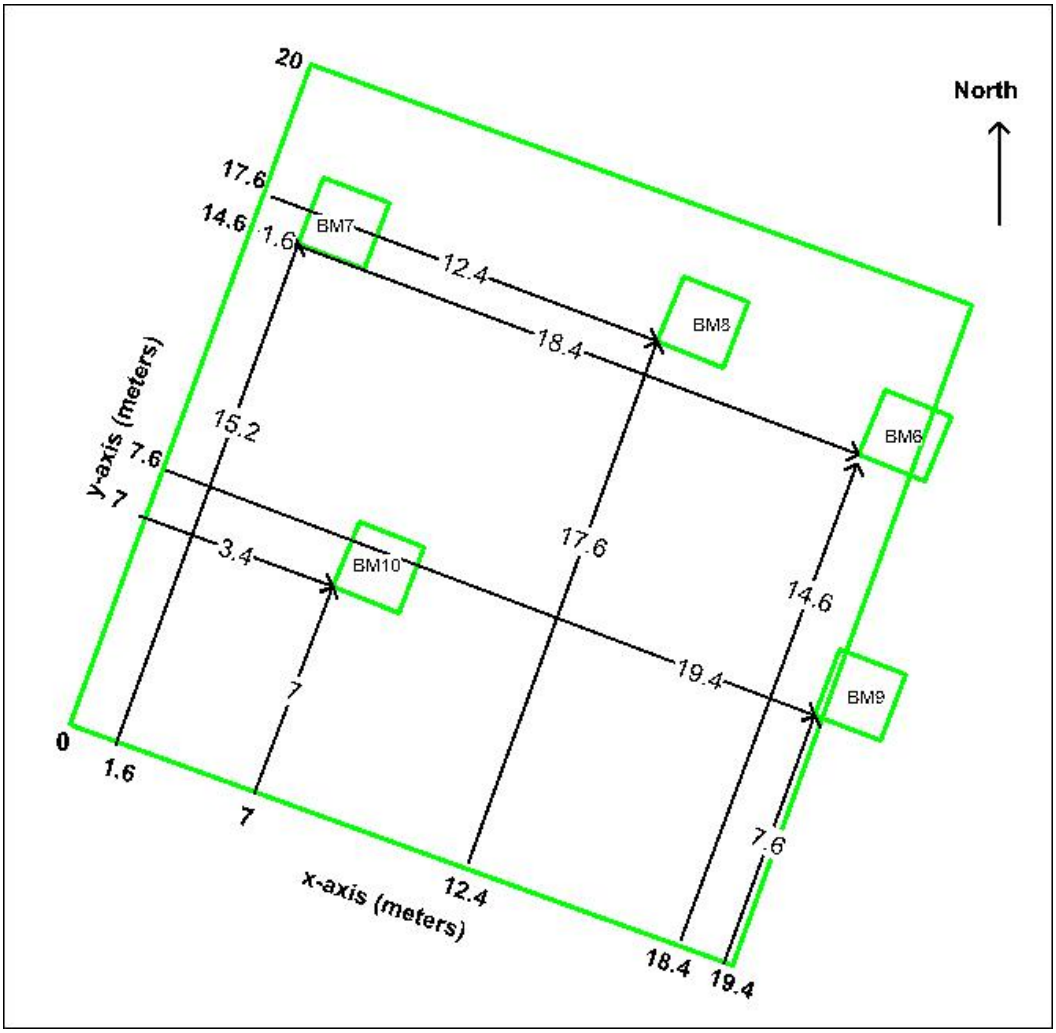


Thematic plan of quadrat locations for Cors Erddreiniog, Bryn Mwcog 'Before and After' Plot 2, M22c, Quadrats BM6 – BM10



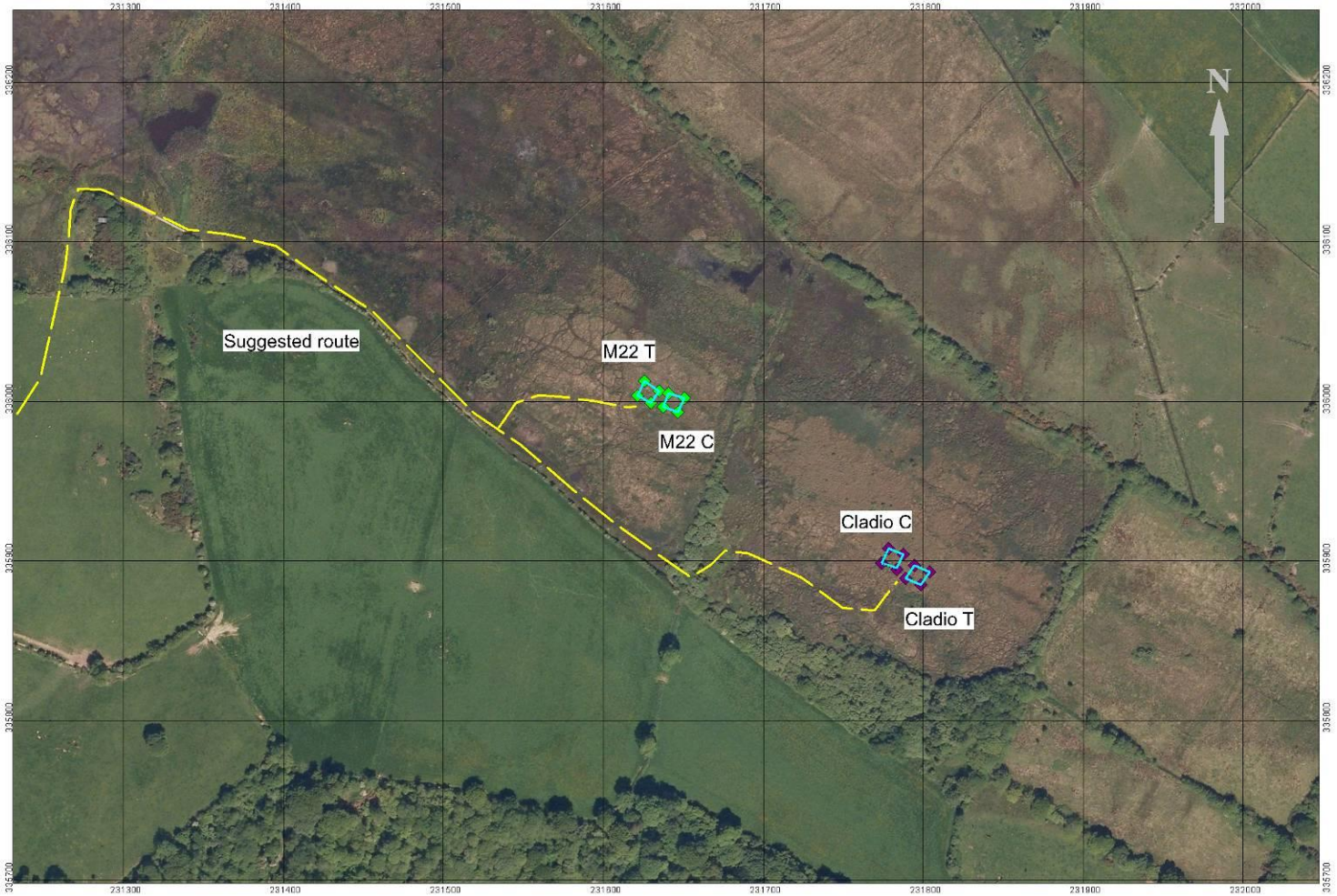
Natural Resources Wales, 100019741 (2014).

- Photos taken from north looking south. Label as 'Bryn Mwcog Plot 2 QBM[6-510] year'.
- Metal plate & cane with plastic sleeve in south west corner of plot & each quadrat.
- Measurements taken (in meters) from south west corner of plot to south west corner of each quadrat.
- Vegetation may be too tall for a Boreman disc measurement.
- 'NW' corner SH4678583150 (7 m)
  'NE' corner SH4680483143 (7 m)
- Can be easier to measure the quadrats from the 'NW' to 'NE' axis, as they are closer.



‘Control & Treatment’ Cors Geirch NNR (Cladio & M22)

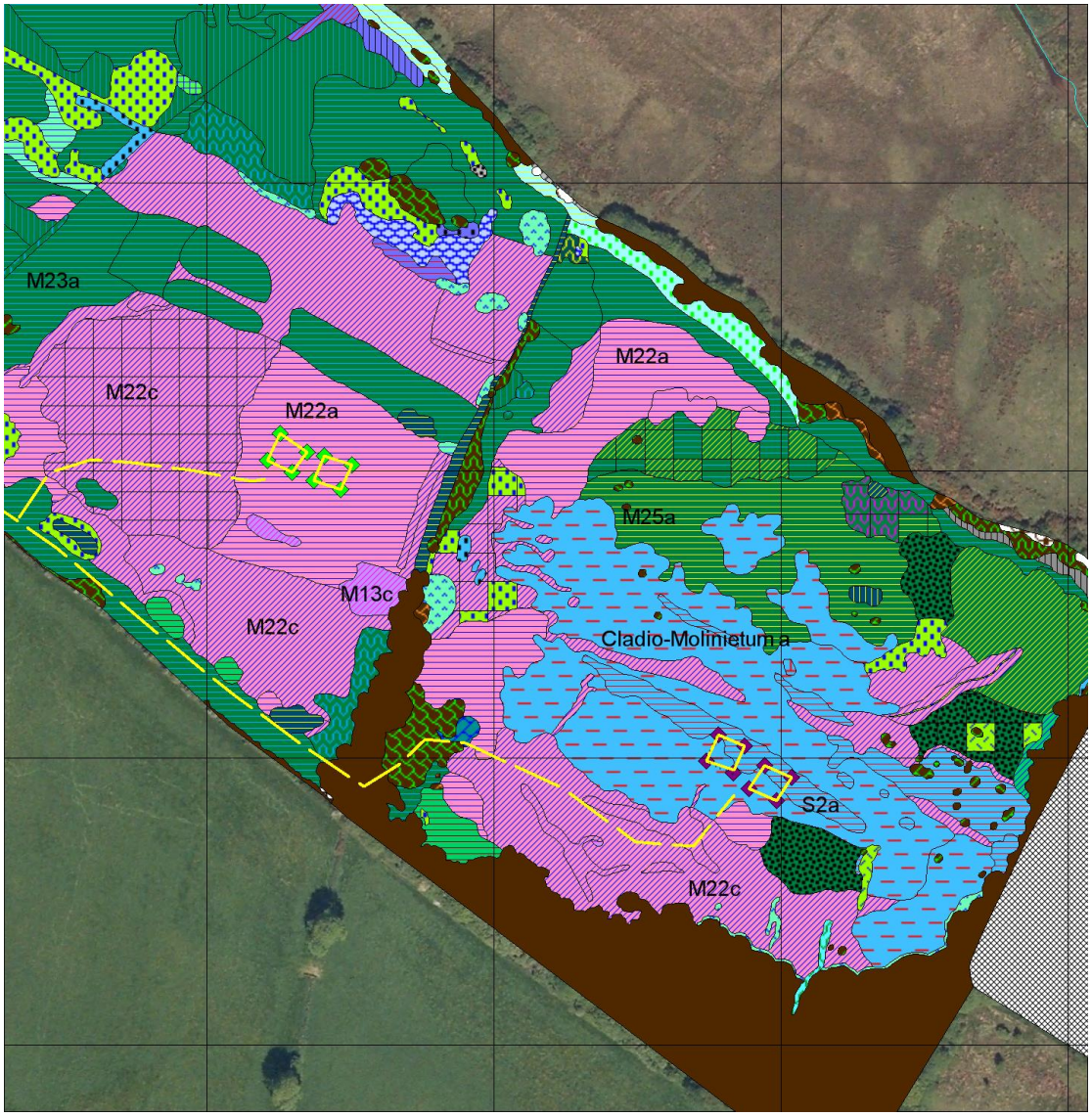
Cors Geirch NNR pair plots vegetation monitoring (M22 & Cladio-molinietum)



Mapped by NRW,
Scale 1:3000

Cyfoeth Naturiol Cymru
Natural Resources Wales

Cors Geirch NNR paired 'Treatment & Control' plots over NVC map



Natural Resources Wales, 100019741 (2014).

Main vegetation types:

Pink with blue stripes = M22 (*Juncus subnodulosus*)

Purple with pink stripes = M13 (alkaline fen with *Schoenus nigricans*)

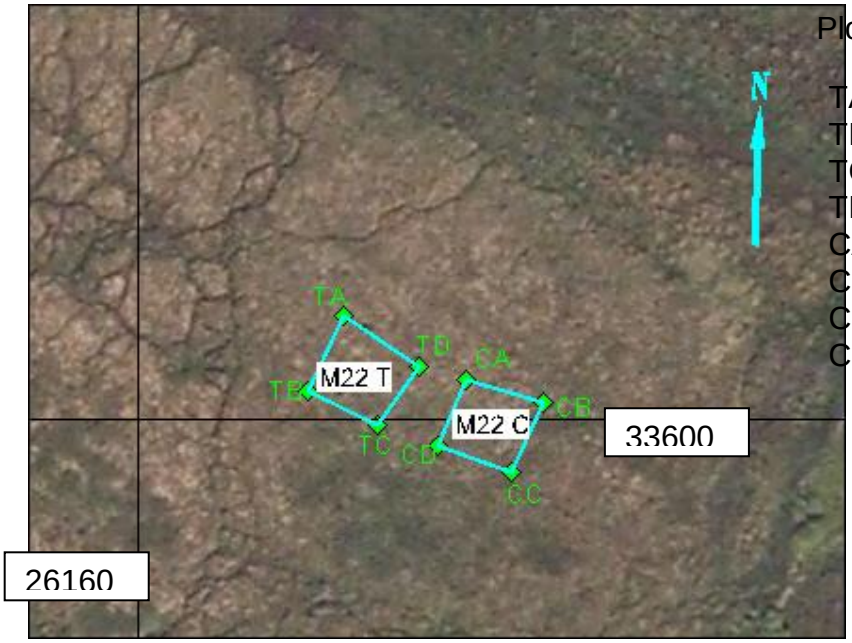
Turquoise with red dashes or red lines = 'Cladio-molinietum' & S2 (*Cladium mariscus*)

Green with turquoise stripes = M23 (*Juncus effusus*/*J. acutiflorus*)

Green with yellow stripes = M25 (*Molinia caerulea*)

Brown = trees/scrub

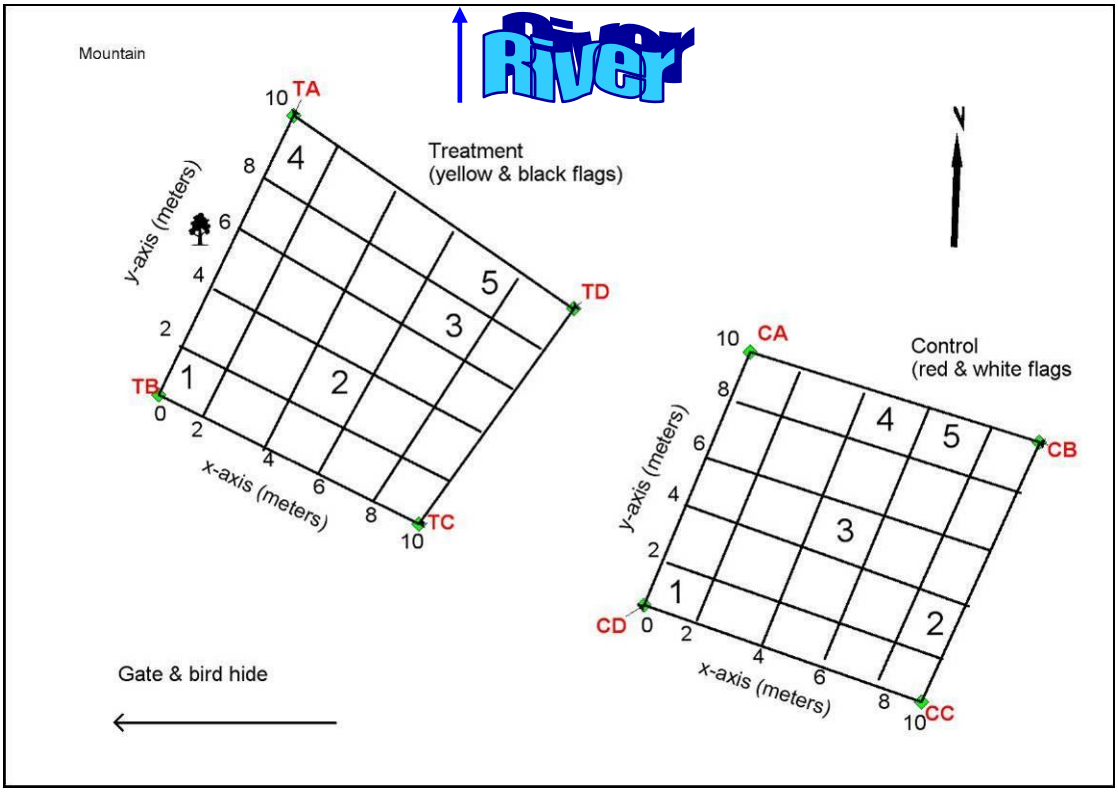
Cors Geirch NNR M22 'Treatment & Control' plots



Plot corners

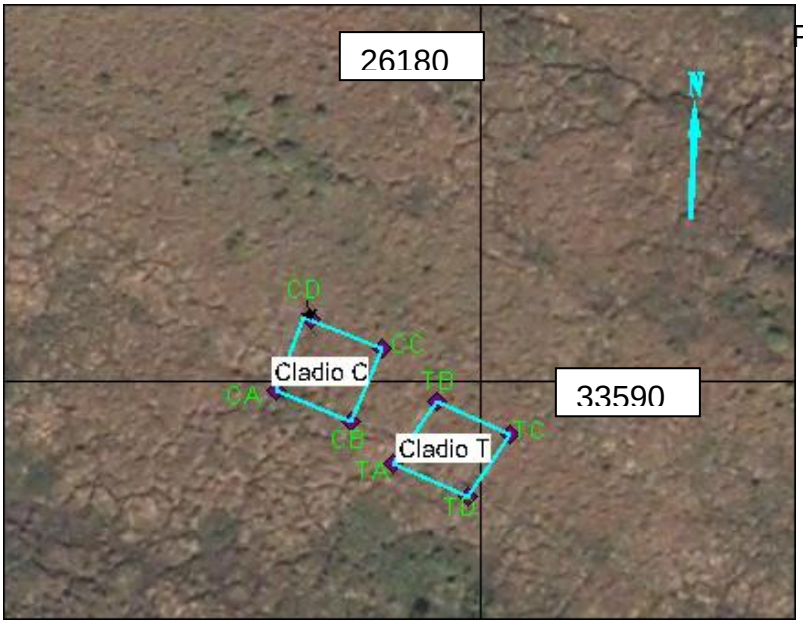
TA	SH3162636013
TB	SH3162136004
TC	SH3163035999
TD	SH3163536006
CA	SH3164136005
CC	SH3164735993
CB	SH3165136002
CD	SH3163735997

- Photos taken from South looking North Label as 'CG-NNR-M22-[T or C]-Q[1-5] year'.



Natural Resources Wales, 100019741 (2014).

Cors Geirch NNR 'Cladio-Molinietum' ''Treatment & Control' plots



Plot corners

CA	SH3177435899
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CC	SH3178735904
CD	SH3177835908
TA	SH3178935889
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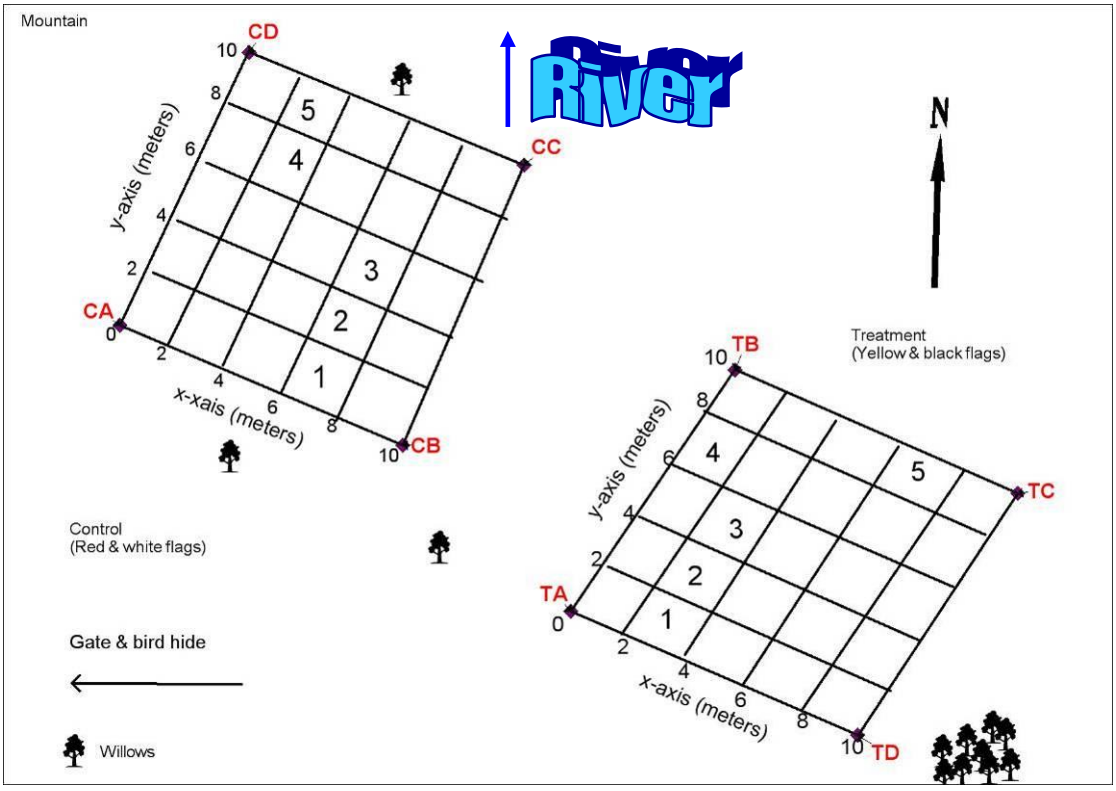
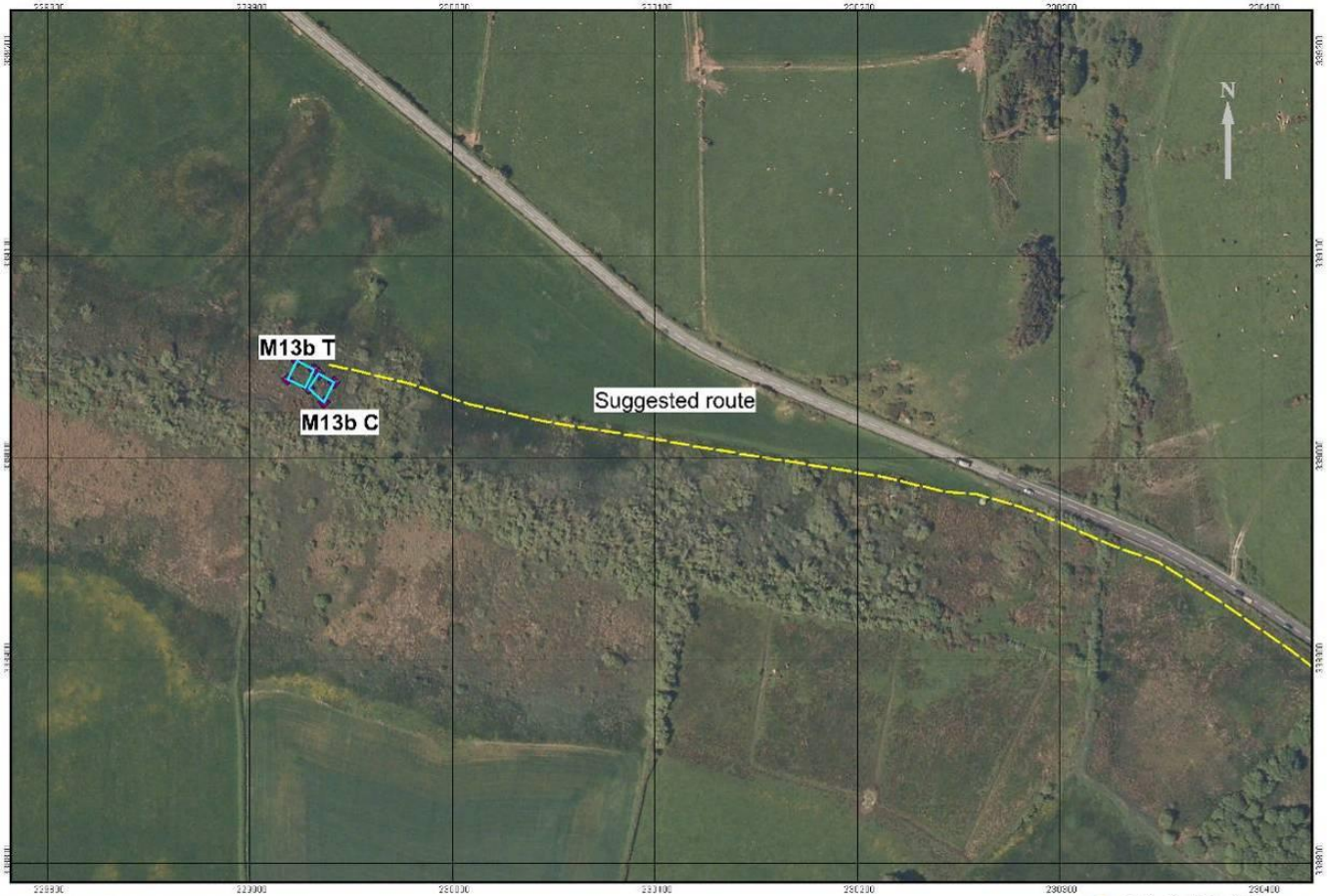
- Photos taken from South looking North Label as 'CG-NNR-Cladio-[T or C]-Q[1-5] year'.



Natural Resources Wales, 100019741 (2014).

‘Control & Treatment’ Cors Geirch, Cors Ffynnon Wen (Bodtacho Ddu)

Cors Geirch Bodtacho Ddu/Ffynnon Wen paired plots vegetation monitoring (M13b)



Produced by NRW on: 5 February 2014

Scale 1:2500

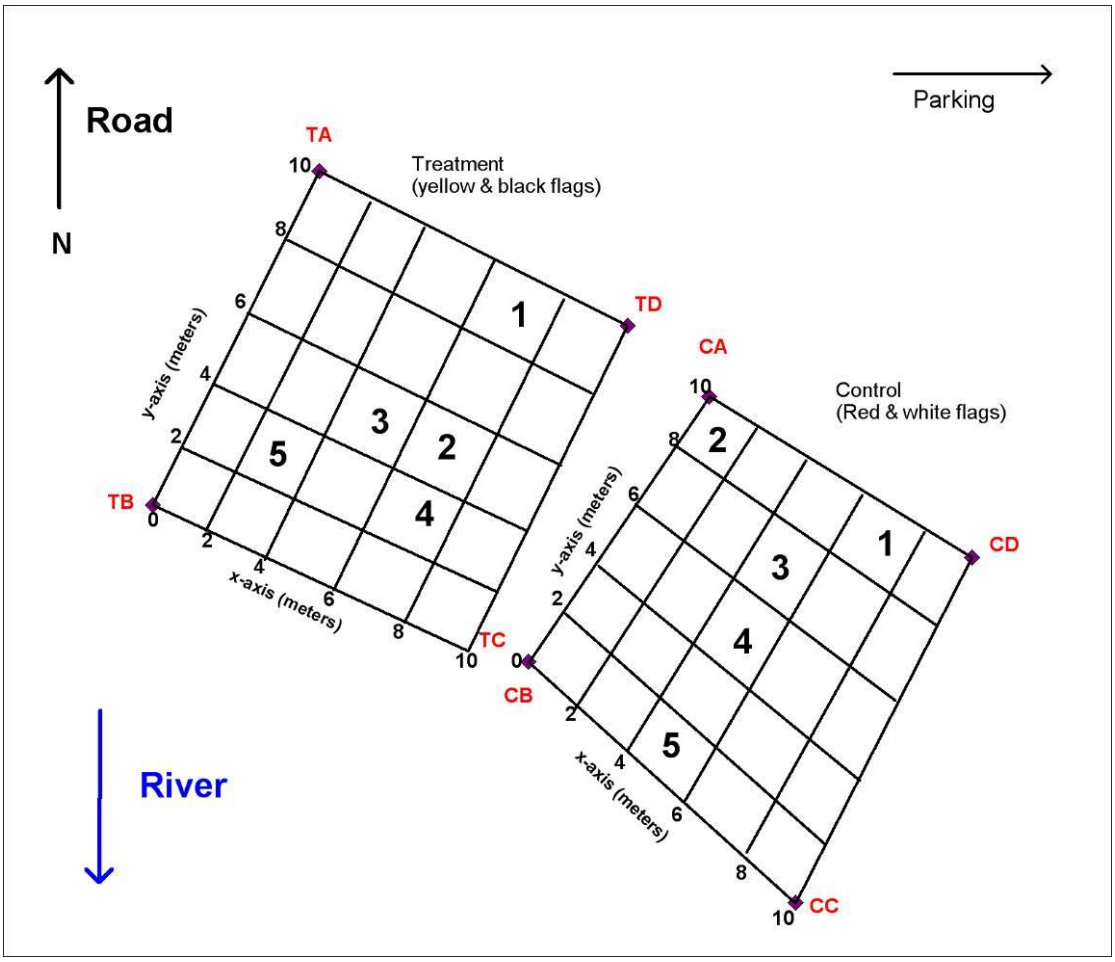
Cyfoeth Naturiol Cymru
Natural Resources Wales

Cors Geirch Ffynnon Wen
(Bodtacho Ddu) 'Treatment & Control' plots

Plot corners

CA	SH29934 39042
CB	SH29929 39035
CC	SH29936 39028
CD	SH29941 39037
TA	SH29923 39048
TB	SH29919 39039
TC	SH29927 39035
TD	SH29932 39044

- Photos taken from South looking North. Label as 'CG-BD-M13-[T or C]-Q[1-5] year'.
- Large gorse bush *Ulex europaeus* in Quadrat T1.
- Park in 'car park' & walk along edge of fields or road to small metal gate. Very busy road.



Natural Resources Wales, 100019741 (2014).