Manchester Geographical Society

Funding Report

Radiocarbon dating of key phases of bog development at Holcroft Moss

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Rationale: Peatlands are highly valuable, yet highly degraded, ecosystems. The extent of their degradation has severely impacted peatland function and ecosystem service provision, including their vital ability to sequester carbon. This is a particularly prominent issue in the UK, where over 80 % of peatlands are classed as degraded (Moxey and Moran, 2014). As such, peatland restoration is a priority in both policy and practice and research to inform restoration and enhanced restoration success is highly valuable. The longer temporal span of palaeoecological research can add a valuable perspective to peatland restoration, providing practitioners with pre-disturbance baseline conditions, a broader range of restoration targets, and insight into site resilience and how it many respond to future pressures (Clarke and Lynch, 2016). However, despite wide advocation for the value of a palaeoecological perspective, it is rarely included in restoration projects. This means there is a persistent research-practice gap between peatland restoration practitioners and palaeoecologists (Birks, 2019).

This study will aim to address this gap by offering a palaeoecological perspective on the restoration of Greater Manchester's peatlands, collaborating with local conservation agencies to produce research which is relevant to restoration practice. Holcroft Moss (OS grid reference SJ 68478 93315) is unusual in that the peat has not been commercially cut, providing a rare and valuable opportunity to investigate the full extent of peatland development and history. This study will undertake a multi-proxy investigation of Holcroft Moss, including pollen and plant macrofossil analysis, testate amoebae analysis, eDNA analysis, and XRF core scanning. This will provide a comprehensive insight into past environmental change, and the impacts of climate change, anthropogenic activity, and heavy metal pollution on the vegetation and microbial community, with a view to disseminate these results into restoration management plans through an ongoing and active partnership with Cheshire Wildlife Trust.

Establishing a chronology through AMS ^{14}C dating allows palaeoecological studies to interpret drivers, timing and rates of environmental change (Parnell *et al.*, 2011). Without a robust chronology, palaeoecological data cannot be confidently interpreted in the context of known climatic or anthropogenic events, such as the Medieval Warm Period or the Industrial Revolution. As such, funding was requested from the MGS for two rangefinder AMS ^{14}C dates in order to establish a chronology, as this is essential for this study to achieve its potential in guiding restoration approaches.

This report presents new chronological data constraining the timings of key phases of bog development for Holcroft Moss SSSI.

Methods

Fieldwork

A 4.47m core was collected from Holcroft Moss in 2021 using a Russian corer and transported in guttering and plastic wrap to the laboratory fridges at the University of Manchester's Geography Laboratory. Permission for the fieldwork was obtained from Cheshire Wildlife Trust and Natural England. The core surface was cleaned using a spatula and visual analysis of the stratigraphy was undertaken using the Troels-Smith Classification.

Radiocarbon analysis

Samples for radiocarbon dating were selected to target key sections of bog development. The sampling strategy targeted the fen-bog transition, indicated in the stratigraphy by a shift from humified peat with frequent ligneous fragments to *Sphagnum* peat, and basal dates of early bog development. Radiocarbon dates were provided by Beta Analytic (USA). Radiocarbon age calibration was undertaken in R (version 3.6.3) using the package Bchron, which utilises Bayesian modelling methods using the algorithm outlined in Haslett and Parnell (2008).

The results of the radiocarbon analysis are shown in Table 1, along with summary of existing dates for Holcroft Moss and a selection of sites in north-west England, for comparison purposes. Site locations are illustrated in Figure 1.

*Table 1: Radiocarbon dates for the current study and obtained from the literature for study site and surrounding sites in the north-west region. All radiocarbon dates have been recalibrated in R using Bchron for this report (with exception; see below); *Original study presented calibrated dates only; dates have been reported here as presented in source study and not recalibrated; **Authors note age reversal and potential contamination of dated material.*

Site	Lab ID	Core depth (m)	Position (cm)	Material	Conventional C^{14} age	Calibrated age (2σ range) cal. BP	Calibrated age (2σ range) cal. BC/AD	Reference
Holcroft Moss	Beta-629803 Beta-629804	4.47	245 385	Plant tissue Bulk peat	2250 ± 30 3330 ± 30	2154 – 2340 3467 – 3679	315-205 cal. BC 1687-1517 cal. BC	Unpublished PhD work (J. Gauld; this study)
Holcroft Moss	Beta-456519 Beta-443587 Beta-440756	0.5	36.5 39.5 46.5	Plant tissue	550 ± 37 560 ± 45 650 ± 37	514 – 642 515 – 647 555 – 669	cal. AD 1308-1437 cal. AD 1303 – 1436 cal. AD 1280 – 1396	Fletcher and Ryan (2018)
Holcroft Moss	-	-	42-47 81-89 121-129 161-169 201-209 241-249 281-289	-	-	410 – 690 770 – 910 950 – 1160 1310 – 1550 1750 – 2010 2140 – 2410 2460 – 2810	-	Wang *et al.* (2023)*
Chat Moss (Astley Moss)	Beta-132269 Beta-120498 Beta-120499 Beta-132270	2.5	16-17 34-35 43-44 239-240	-	280 ± 60 2140 ± 50 2380 ± 60 4460 ± 40	266 – 497 1993 – 2308 2314 – 2547 4960 – 5292	cal. AD 1458-1684 235-43cal. BC 598-364 cal. BC 3344-3011 cal. BC	Davis and Wilkinson (2004)
Chat Moss (Barton Moss)	GU-5366 GU-5367 GU-5368 GU-5369 GU-5370 GU-5372 GU-5372	4.0	20-30 70-80 105-115 152-162 215-225 330-360 380-400	Peat (humic acid)	3280 ± 50 4300 ± 60 4870 ± 60 6020 ± 60 6850 ± 60 8480 ± 50 7750 ± 60**	3389 – 3631 4798 – 5047 5473 – 5734 6728 – 7004 7580 – 7793 9424 – 9540 8411 – 8608	1642-1439 cal. BC 3098-2849 cal. BC 3785-3524 cal. BC 5056-4779 cal. BC 5844–5630 cal. BC 7593-7475 cal. BC 6659-6461 cal. BC	Hall *et al.* (1995); Bayliss *et al.* (2015)
Chat Moss (Rindle Moss)	UBA-48939 UBA-48940	3.6	100 246	Bulk peat	3177 ± 30 4829 ± 29	3355 – 3452 5478 – 5599	1505-1405 cal. BC 3650-3528 cal. BC	Unpublished PhD work (J. Gauld)
Chat Moss	Q-683 Q-682	-	3-5 14-16	Peat	2645 ± 100 3070 ± 150	2425 – 2965 2857 – 3576	1017-475 cal. BC 1630-907 cal. BC	Godwin and Switsur (1966); Hall *et al.* (1995)
Chat Moss (Nook Farm)	GU-5356 GU-5272 GU-5325 GU-5354 GU-5280 GU-5271 GU-5273	0.55	5-10 38-48 - 5-10 - 25-40 30-40	Peat (humic acid; Eriophorum) Peat (wood peat) Wood (carbonised) Wood and peat (humic acid) Wood (waterlogged) Peat (wood peat) Peat (wood peat)	2170 ± 50 3710 ± 60 3930 ± 80 4020 ± 50 4570 ± 50 4590 ± 70 4670 ± 60	2043 – 2319 3891 – 4236 4145 – 4578 4403 – 4796 5047 – 5448 5041 – 5474 5300 – 5579	371-93 cal. BC 2240-1941 cal. BC 2630–2195 cal. BC 2696-2453 cal. BC 3380-3098 cal. BC 3526-3091 cal. BC 3539-3350 cal. BC	Hall *et al.* (1995); Bayliss *et al.* (2013; 2015)
Walker's Heath	GU-5606 GU-5605 GU-5604 OxA-6140 OxA-6139	3.0	80-90 110-120 125-135 244-246 260-262	Peat (humic acid; Eriophorum Calluna)	5904 ± 50 7180 ± 120 7910 ± 50 9220 ± 75 9450 ± 90	6626 – 6856 7737 – 8209 8597 – 8983 10241 – 10565 10493 – 11097	4907 – 4676 cal. BC 6261 – 5787 cal. BC 6865 – 6647 cal. BC 8619 – 8291 cal. BC 9151 – 8543 cal. BC	Leah *et al.* (1997); Hedges *et al.* (1996); Bayliss *et al.* (2015)

*Table 1 (cont.): **Authors note age reversal and potential contamination of dated material;*
**** Depth inferred from stratigraphic diagram; actual core depth not reported in literature.*

Site	Lab ID	Core depth (m)	Position (cm)	Material	Conventional C^{14} age	Calibrated age (2σ range) cal. BP	Calibrated age (2σ range) cal. BC/AD	Reference
Red Moss	GU-5374	c. 3.3 – 3.5***	-	Peat	1260 ± 50	1069 – 1287	663 – 881 cal. AD	Hibbert *et al.* (1971); Bayliss *et al.* (2015); Hall *et al.* (1995)
	GU-5373		-	Peat	2260 ± 50	2147 – 2350	402 – 197 cal. BC	
	GU-5375		-	Peat	2330 ± 50	2155 – 2668	544 – 349 cal. BC	
	Q-910		114-116	Peat	4370 ± 80	4830 – 5286	3196 – 2880 cal. BC	
	Q-911		124-126	Peat	4715 ± 80	5304 – 5592	3645 – 3354 cal. BC	
	Q-912		132-134	Peat	5010 ± 80	5599 – 5904	3957 – 3649 cal. BC	
	Q-913		139-141	Peat	5060 ± 80	5603 – 5934	3986 – 3653 cal. BC	
	Q-914		158-160	Peat	5399 ± 100	5987 – 6323	4402 – 4037 cal. BC	
	Q-915		225-227	Peat	6880 ± 100	7572 – 7877	5929 – 5622 cal. BC	
	Q-916		230-232	Peat	7107 ± 120	7692 – 8170	613 – 5742 cal. BC	
	Q-917		237-239	Peat	7460 ± 150	8003 – 8540	6592 – 6052 cal. BC	
	Q-918		259-261	Peat	8196 ± 150	8720 – 9485	7538 – 6768 cal. BC	
	Q-919		269-271	Peat	8742 ± 170	9481 – 10216	8273 – 7530 cal. BC	
	Q-920		290-292	Peat	8790 ± 170	9526 – 10236	8289 – 7576 cal. BC	
	Q-921		296-298	Peat	8880 ± 170	9537 – 10299	8353 – 7587 cal. BC	
	Q-922		305-307	Peat	9456 ± 200	10247 – 11207	9266 – 8295 cal. BC	
	Q-923		310-312	Peat	9586 ± 200	10285 – 11397	9450 – 8322 cal. BC	
	Q-924		320-322	Peat	9798 ± 200	10646 – 11839	9928 – 8697 cal. BC	
	Q-925		325-330	Peat	9508 ± 200**	10255 – 11242	9299 - 8301 cal. BC	
Worsley Farm	GU-5359	4.3	33-42	Peat (humic acid)	3280 ± 60	3382 – 3637	1689 – 1432 cal. BC	Hall *et al.* (1995); Bayliss *et al.* (2015)
	GU-5360		64-66		4050 ± 70	4405 – 4824	2876 – 2455 cal. BC	
	GU-5361		70-77		4320 ± 50	4825 – 5041	3046 – 2876 cal. BC	
	GU-5362		110-113		4950 ± 60	5585 – 5892	3815 – 3636 cal. BC	
	GU-5363		150-160		5270 ± 50	5929 – 6188	4240 – 3980 cal. BC	
	GU-5364		300-320		7980 ± 80	8601 – 9014	7067 – 6651 cal. BC	
	GU-5365		410-430		9140 ± 70	10196 – 10497	8495 – 8247 cal. BC	
Lindow Moss	GU-5559	-	-	Peat (humic acid)	3280 ± 70	3368 – 3643	1695 – 1419 cal. BC	Lageard *et al.* (1996); Leah *et al.* (1997); Bayliss *et al.* (2015)
	GU-5563		8-9	Peat (humic acid)	4220 ± 60	4571 – 4870	2921 – 2622 cal. BC	
	GU-5561		-	Peat (humic acid)	4040 ± 70	4399 – 4821	2783 – 2448 cal. BC	
	GU-5562		40-41	Peat (humic acid)	4060 ± 70	4412 – 4823	2787 – 2462 cal. BC	
	GU-5560		-	Peat (humic acid)	4940 ± 50	5586 – 5861	3804 – 3637 cal. BC	
	GU-5569		-	Wood	5150 ± 50	5841 – 5998	4050 – 3797 cal. BC	
	GU-5567		-	Wood	5190 ± 50	5758 – 6175	4071 – 3938 cal. BC	
	GU-5568		-	Wood	5260 ± 70	5907 – 6202	4254 – 3957 cal. BC	
	GU-5570		-	Wood	5330 ± 80	5986 – 6282	4334 – 4036 cal. BC	
	GU-5565		79-81	Peat (humic acid)	5570 ± 60	6281 – 6486	4538 – 4331 cal. BC	
	GU-5564		127.5-129	Peat (humic acid)	7140 ± 80	7791 – 8168	6103 – 5841 cal. BC	
	GU-5566		163.5-165.5	Peat (humic acid)	7780 ± 70	8407 – 8729	6822 – 6457 cal. BC	
Danes Moss	GU-5602	5.0	230-235	Peat (humic acid *Sphagnum*)	3150 ± 50	3238 – 3455	1507 – 1287 cal. BC	Leah *et al.* (1997); Bayliss *et al.* (2015)
	GU-5603		492-500	Wood and peat (humic acid)	6670 ± 60	7430 – 7618	5670 – 5480 cal. BC	

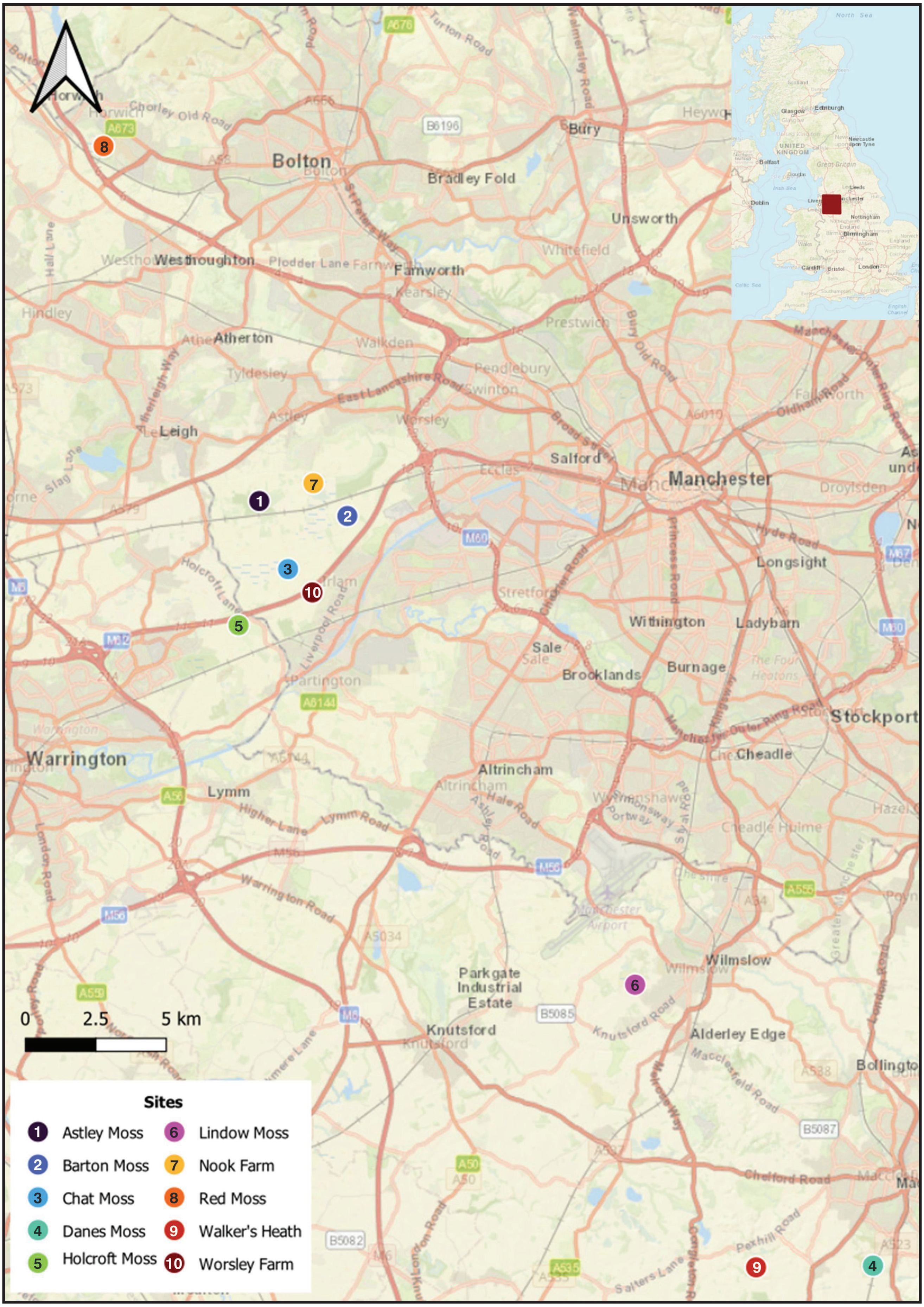

Figure 1: Location of study site (Holcroft Moss) and surrounding sites

Discussion

Early bog development occurs *c.* 3594 – 3479 cal. BP. This is later than suggested by Birks (1965), whose study suggests, through pollen analysis and stratigraphic comparison with dated sequences, that the basal deposits of Holcroft Moss include evidence of the Elm Decline (*c.* 6347 – 5281 cal. BP in the British Isles; Parker *et al.,* 2002). However, the dates presented here agree with more recent studies (Wang *et al.,* 2023). It must be noted that radiocarbon dates are absent from Birks' (1965) study and the site extent has been reduced in recent decades, which may have resulted in the loss of deeper sections of the site.

The data presented here suggests that Holcroft Moss is younger than the surrounding Chat Moss complex and other sites within the north-west region. This aligns with Hall *et al.*'s (1995) postulated asynchronous mire development within the region. The fen-bog transition at Holcroft Moss also appears to have occurred later than other sites, with results indicating it occurred *c.* 2154 – 2340 cal. BP. The noted stratigraphical shift as this point is in agreement with Birks (1965). In contrast, Astley Moss appears to have undergone a fen-bog transition c.2000 years before Holcroft Moss, with a shift out of a stable *Sphagnum* state coinciding with the suggested fen-bog transition at Holcroft Moss. Both these events occur within the timeframe of several well-documented shifts of varying magnitude to wetter conditions *c.* 2000 – 3000 cal. BP (Barber and Charman, 2003; Barber *et al.,* 2003; Elliss and Tallis, 2000; Hughes *et al.,* 2000; Chiverrell *et al.,* 2008; Charman, 2010; Charman *et al.,* 2006).

This report presents new radiocarbon data which may aid interpretation of the timings of key phases of bog development at Holcroft Moss. Further palaeoecological study will help to corroborate this analysis.

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