DRIVERS OF LONG-TERM AQUATIC PLANT CHANGE IN UPLAND LAKES AND STREAMS IN THE UK: A DNA APPROACH

Background and Rationale

The analysis of DNA preserved in soils and sediments is increasingly being used as a tool in environmental research, particularly palaeolimnology (Capo et al., 2021). The primary aim of this element of the PhD is to examine the scientific potential of plant sedDNA in lake sediments for reconstructing the past aquatic plant assemblages in a low-alkalinity upland lake, the Round Loch of Glenhead. A secondary aim will determine whether littoral or deep-water cores provide the best archive for plant sedDNA. Validation of sedDNA results will be done through comparison with three-decades of historic biomonitoring archives of aquatic plant abundances and distribution records from the UK Upland Waters Monitoring Network (Battarbee et al., 2014). Robust sediment core chronologies are essential to the interpretation of any sedDNA results.

Methods and Results

Deep-water (RLGHE2) and littoral (RLGHE3) cores were collected on 14th Sept 2020 using an HTH Renberg gravity corer, from 12.1m and 3.5m water depths respectively. Cores were kept refrigerated in the dark until extrusion at 0.25cm increments in a clean room where no previous DNA work had been performed. Two replicates for each level were sampled and frozen immediately. DNA extractions were performed on selected levels using QIAGEN PowerSoil Pro kits. DNA concentrations were measured using a Qubit fluorometer and DNA purity using a Nanodrop spectrophotometer. Sediment sub-samples were analysed for wet density, percentage dry weight and loss on ignition. Selected levels were dried and sent to the UCL Environmental Radiometric Facility for radiometric dating using ^{210}Pb, and isotope spikes of ^{137}Cs and ^{241}Am, to establish core chronologies. PCR analyses of the DNA samples are ongoing, using the trnL barcode developed for characterising plant species from degraded sediment and archaeological samples (Taberlet et al., 2007). Amplicon libraries will be sequenced on an Illumina MiSeq machine.

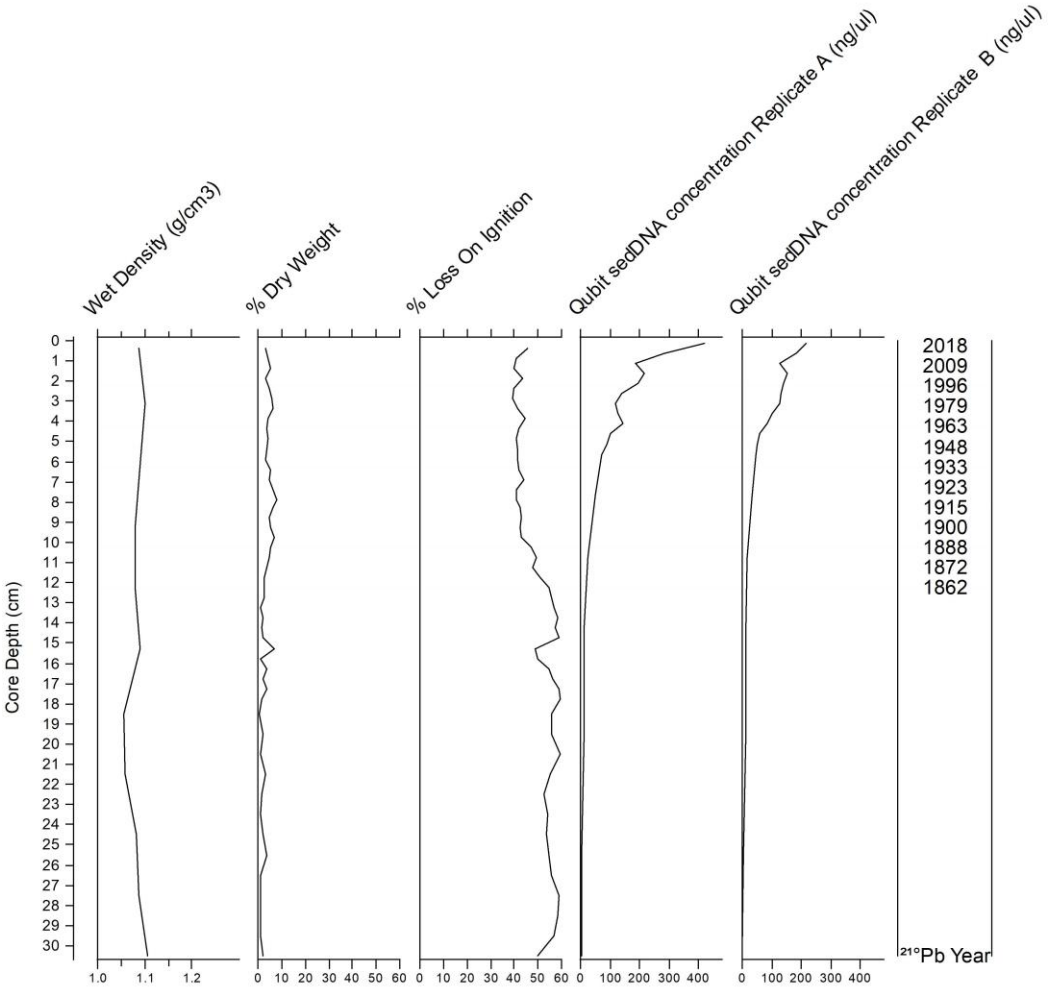

Figure 1. Deep-water core RLGHE2. Sediment sample wet densities, dry weights, loss on ignition, DNA concentrations and chronology.

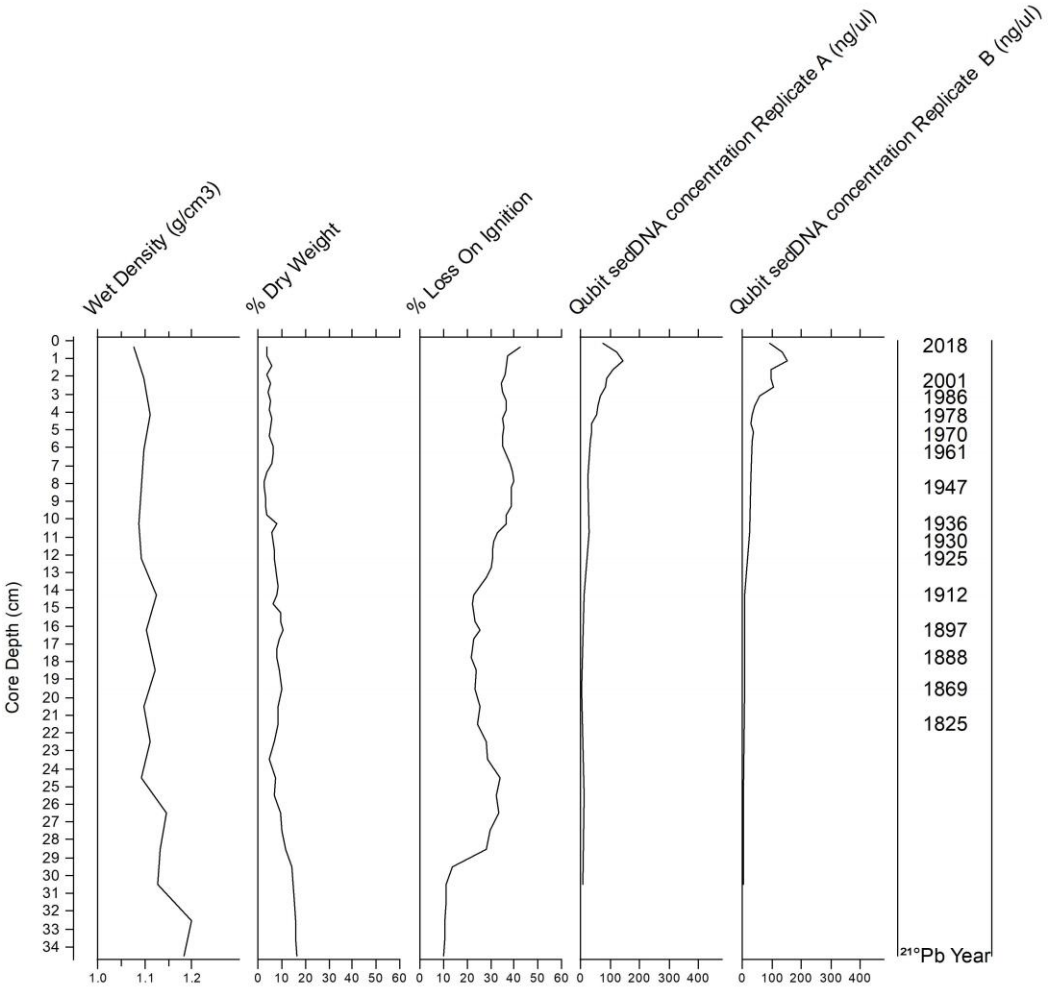

Figure 2 Shallow-water core RLGHE3. Sediment sample wet densities, dry weights, loss on ignition, DNA concentrations and chronology.

Table 1 ^{210}Pb chronology of deep-water core RLGHE2

Depth	Dry_mass	Chronology			Sedimentation Rate		
		Date	Age				
cm	g cm^{-2}	AD	yr	±	g cm^{-2} yr^{-1}	cm yr^{-1}	± %
0	0	2020	0				
0.25	0.0093	2018	2	2	0.0057	0.121	9.5
1.25	0.0585	2009	11	2	0.0046	0.092	12.6
2.25	0.1094	1996	24	2	0.0032	0.059	9.3
3.25	0.1661	1979	41	3	0.0036	0.064	12.6
4.25	0.2208	1963	57	3	0.0033	0.06	16.6
5.25	0.274	1948	72	4	0.0038	0.073	15.7
6.25	0.3253	1933	87	6	0.0034	0.061	23.4
7.25	0.3837	1923	97	7	0.0127	0.215	82.4
8.25	0.4436	1915	105	8	0.0044	0.074	31.5
9.25	0.5034	1900	120	12	0.0034	0.064	50.4
10.25	0.5492	1888	132	16	0.0046	0.101	70.6
11.25	0.5949	1878	142	20	0.004	0.087	98.1
12.25	0.6407	1862	158	30	0.0021	0.043	106.5

Table 2 ^{210}Pb chronology of shallow water core RLGHE3

Depth	Dry mass	Chronology			Sedimentation Rate		
		Date	Age				
cm	g cm^{-2}	AD	yr	±	g cm^{-2} yr^{-1}	cm yr^{-1}	± %
0	0	2020	0				
0.25	0.0091	2018	2	2	0.0061	0.152	23.4
2.25	0.0898	2001	19	6	0.0035	0.077	39.9
3.13	0.1387	1986	34	6	0.0049	0.087	63.9
4.25	0.2033	1978	42	6	0.0082	0.132	11.6
5.25	0.2705	1970	50	6	0.0083	0.122	12.1
6.25	0.3397	1961	59	6	0.0066	0.109	12.3
7.25	0.3917	1953	67	7	0.0068	0.134	9.5
8.25	0.4412	1947	73	7	0.0089	0.172	13.1
9.25	0.495	1941	79	8	0.0119	0.221	14.8
10.25	0.5488	1936	84	8	0.0086	0.125	18.4
11.25	0.6335	1930	90	9	0.0258	0.305	41.8
12.25	0.7182	1925	95	9	0.0127	0.149	29.2
14.25	0.8876	1912	108	11	0.0123	0.134	35.9
15.25	0.993	1904	116	12	0.0136	0.129	41
16.25	1.0983	1897	123	13	0.0176	0.163	49.2
17.75	1.2628	1888	132	15	0.0193	0.182	76.5
19.5	1.4427	1869	151	18	0.0051	0.053	53.9
21.5	1.6256	1825	195	35	0.0029	0.034	61.1

Loss on ignition and percent dry weight in both cores (Figures 1 and 2) indicate organic sediments and values are consistent with historic cores from the same site (Jones et al., 1989). Values changed little down the profile in the deep core whereas the shallow core was slightly more minerogenic in the bottom 5cm. The dating report (Yang, 2021) indicated that both cores have undisturbed chronologies (Tables 1 and 2), with the maximum measurable age of the deep core 1862 ±30 at 12.25cm depth and that of the shallow core 1825 ±35 at 21.5cm depth. The sediment accumulation rate was higher in the shallow-water core than the deep-water core but both fall within the range of rates that Allot et al. (1992) observed in a multi-core study of the site. Sediment DNA concentrations were higher in the deep-water core than the shallow-water core and declined with depth in both replicates from both cores. Even at the bottom of the cores however, DNA concentrations are sufficient for PCR analyses. Both replicates in the shallow core show a slight decline in concentrations at the surface.

Significance

Establishing that both cores represent undisturbed continuous records of the time period of interest in this project provides confidence that stratigraphical interpretations of the DNA analyses will be robust. If sedDNA from sediment cores matches known aquatic plant species occurrences, then down-core results from the most representative coring location can be used to establish pre-acidification ecological baselines and address whether aquatic plants are returning to pre-industrial assemblages or are responding to nutrient deposition and changes in climate. If the sedDNA technique is sufficiently accurate and sensitive, then core surface sediment or annual sediment trap samples may provide statutory bodies with an innovative and more cost-effective methodology for characterising and monitoring aquatic plants than current traditional surveys.

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